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Exploring Electronics And Technology For The Hobbyist And Professional

March 1999 Vol. 20 No. 3

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Columns ...

DEPARTMENTS

CLASSIFIED AD INDEX

Some Practical Light Meters — Part 1

by Evert Fruitman W7RXV

An old saying in photography goes no light, no picture.

Too much or too little light results in a bad picture. As a professional photographer explained it to me, playing with the f-stops on the enlarger, as well as the timing, and then juggling the darkroom chemistry may get me a usable picture, still, nothing takes the place of the correct exposure. That holds true especially with slower color films.

For years, professional photographers have used light meters to help them determine the correct exposure. In order to make sure that we have the correct exposure, we will look at several practical ways to measure the amount of light that your camera sees; then we will look at some ways to customize a light meter that will best meet your particular needs.

History

Some of the earliest light meters consisted of a self-generating photo cell, a calibrating resistor, a filter, a dial or two, and a meter. The self-generating photo cell — usually selenium — fed a sensitive microammeter through a factory-selected resistor. The filter went over the pickup area in bright light, giving the meter an INCIDENT and a REFLECTED range. The dial(s) usually had enough numbers and symbols to confuse a mathematician. Figure 1 shows a typical circuit.

In rather dim light, and with the common slow film of the day, the photographer may have had to make a long, slow exposure. But, once he found out how to correlate the meter reading, the dial setting, and the film speed, he could get relatively consistent negatives and transparencies.

Under those conditions, you may have to make a long, slow exposure too, but, you will have a less confusing, simpler, light meter. We will try to keep our systems simple, understandable, and practical.

Measuring Light Levels

The self-generating system just described will give an indication of the light level, however, using a light-dependent resistor (LDR) as the sensing element offers some advantages over the self-generating photo cell. Although the LDR needs a battery, it allows the use of a less sensitive, and therefore a less expensive meter movement. Instead of measuring light levels in terms of voltage, the system with the LDR measures light levels in terms of resistance. It amounts to an ohmmeter calibrated in terms of light levels.

An Ohmmeter/Light Meter

In Figure 2, the meter, with R1 and R2, make up a simple voltmeter that matches the meter to the range of the expected battery voltages: in essence, a basic, single-range ohmmeter. You calibrate the meter for a full scale reading with R1. Basically, you "zero," or recalibrate the meter, the same as you would an analog ohmmeter. Note where you find zero ohms on most analog meters: the right-hand end of the scale. The range resistor, R3, determines the general range of resistance that you can measure. For an ohmmeter with a value of 50 ohms for R3, you could measure resistors from about 5 ohms to 10,000 ohms. You would get your best resolution from 5 ohms to 2,000 ohms. Above about 3,000 ohms, the readings get crowded next to each other making them hard to read; at which point you would most likely change ranges to get better resolution. On a higher resistance range, the readings above 3,000 ohms move to the upper end of the meter scale making them easier to read, and with greater accuracy.

PHOTO A. Simplest, practical light meter. You supply the readout, analog or digital ohmmeter. Mini plug connects to meter and plugs into jack on left side of box.

PHOTO B. Interior of simplest light meter. CdS photo cell, mounting detail. Same as analog system, but without diffuser. That makes this one good for reflected-light measurements.

To avoid crowding the readings and in order to give several useful ranges, an analog ohmmeter switches several resistors into the circuit in place of R3. Typical values might be 10, 100, 1,000, 10,000, and 1,000,000 ohms. By using resistors that change in steps of 10, the manufacturer can use the same scale on the meter and just put a multiplier on the range switch: RX1, RX10, RX100 ... RX1,000,000. The higher ranges (above 1,000 ohms) need a higher voltage battery.

With a value of 50 ohms for R3, the center-scale reading would equal 50 ohms. Now, if we pick an LDR with a nominal resistance of 60 ohms in sunlight and around 4,500 ohms in normal room light, we could use a single range resistor for R3 that would let us make a simple, but practical, light meter. For wider ranges of light levels, we could add one or two resistors and a switch, or for easier construction, we could use an autoranging, digital volt-ohmmeter such as the one shown in Figure 3.

The circuit of Figure 3 proved invaluable in a laboratory situation where the researchers had to contend with varying light levels and they did not mind making up a calibration chart just one time. Their main concern was reading a wide range of light levels and knowing how much they varied from day to day. Without the light meter, they got stuck doing several hours of 'wet' chemistry. They told me that even after several years of intermittent use, it still gives consistent measurements. They spent under $30.00 for the autoranging DMM and the photo cell — most likely the cheapest instrument in their laboratory. Probably, it cost less than the coffee pot.

A photographer might find a calibration chart somewhat of an inconvenience, although if the same film is used most of the time, an autoranging ohmmeter and a calibration chart would make a simple, effective, and useful photographic tool. Take a look at Photo A. That combined with an analog or an autoranging digital multimeter, makes an almost instant light meter — with an absolute minimum expenditure of time and money. Photo B gives an up-close look at the works of the simplest light meter. This one uses a CdS cell, a mini phone jack, a plug, and two clips for connecting to your multimeter. Although Photo B shows a CdS photo cell, it will work with a photo transistor. You would have to make up your own calibration chart for that light meter.

If you use a completely home-built, simple system such as the ones shown in Figure 2 or Figure 3, then you could use a simple calibration chart like the one in Table I. That would work for an analog readout and

the circuit of Figure 2. The meter may have a scale with 0-10, 0-15, or some other convenient markings on it. Table I assumes that the meter is marked 0-10. I have on the work bench an old, commercially-built light meter with a 0-10 scale. Joe, at our local Tempe Camera, gave it to me because the original dial which related the numbers to exposures had long since disappeared. It has a diffuser for incident/reflected light. However, without that missing dial, it still needs a calibration chart.

With an arbitrary scale of say 1-10, the calibration chart would suggest exposure values. They would range from a fast shutter speed with a wide f stop to a slow shutter speed with a small f stop. The one would stop action, while the other would give better depth of field, that is, better overall focus. Table I shows a calibration chart for indoor use with a film speed of 200-250.

PHOTO C. Analog light meter. After recording a strobe light burst, before pressing the RESET button.

This simple chart shows just two light levels. It also shows where the early light meters got their dials with their multiplicity of numbers. You would use the first part of the chart with low to medium light levels. The second part is for a well-lit scene. Note that for best depth of field with low to medium light, the chart calls for an exposure of one second with an f stop of 16, or two seconds with the lens set for f 22. Those exposure values indicate still life rather than pictures of lively pets or children in action.

For action shots, you would need flash, faster film, or both. With light levels in the second part of the chart, you can stop action and get reasonable depth of field. I usually find the real world somewhere in between and use a faster film for the birthday parties, with the slow film reserved for still life such as the pictures you see here.

Additional Uses

The autoranging digital meter with a photo cell, or an amplified light meter can give readings in areas with extremely low light levels where pictures would need extra long exposure, fast film, flash, or some combination of those items. The nature of the picture would, in part, determine the photographer's choices. An amplified light meter proved most useful in one other place: the darkroom.

In the Darkroom

If you have had the pleasure of making your own enlargements, you noticed that making several sizes of prints from the same negative required different exposures. As the enlarger head went up, making the picture bigger, the exposure time increased, or you had to open up the lens in order to maintain the same exposure time and get the same print density. After you determine the correct exposure for the first print, an amplified light meter can show you what light level gave that exposure, allowing you to adjust the f stop for the same light level at the focal plane (on the paper) with the enlarger head higher or lower than it was for the original exposure.

Just opening up the enlarger lens to recheck focus and then resetting the lens for the same f stop can give unexpected results. Sometimes the iris has a bit of hysteresis in it. One of my enlargers varied as much as two click-stops. Although it showed f 8, the prints, and later the meter, indicated otherwise.

That explained some of the variations in my print densities. With the colored filters used with multi-contrast paper, my eye simply did not pick up the difference.

Those unexplained variations in my prints made me start looking for causes. Ordinary light meters lack the sensitivity needed to respond in the darkroom. So, out came the calculator and the soldering iron. Several hours, a couple of opamps, and a couple of LEDs later, I had a single range instrument and the answers to some nagging questions.

You can make a multiple range, amplified meter for darkroom, as well as for inside and outside use. Although a bit more complex than the simple systems mentioned so far, it could be the answer to several of your needs. At a later time, if there is enough interest in it, we can give the details of how it works, how to make it, and how to use it.

Outside Meters

Possibly, except for the darkroom or a dimly lit scene, the amplified light meters of Figures 4 and 5 offer little advantage over the simple meter made with a CdS cell, a battery, and a readout (Figure 6).

The light meter shown in Figure 5 gives two ranges with an expanded scale for inside use. However, it is more educational than practical because it needs a 10 uA meter or an op-amp to drive a less sensitive meter. The circuit does illustrate a functional system with the use of another semiconductor to give temperature compensation in a simple circuit.

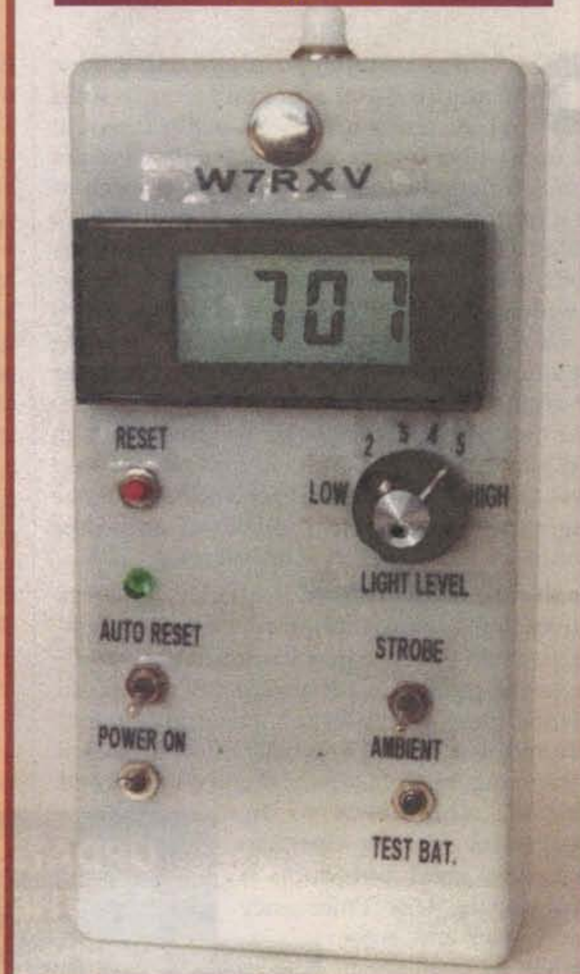
The circuits of Figures 4 and 6 start to become practical. By using a form of a Wheatstone bridge, you can use less sensitive meters, and with a transistor in both legs of the bridge (Figure 4), you get temperature compensation. At the expense of some versatility, you could leave off the 1K pot, as well as the 4,700-ohm resistor, and replace the first transistor with a diode that would cut the parts count and still give temperature compensation.

While they work, I decided against having to balance a Wheatstone bridge for each light measurement. Figures 11 and 12 show the method that I finally wound up using. Those are the combined ambient/strobe meters. Figures 7-10 give the basic ambient/strobe instruments with analog/digital display. That may make it easier to see what goes into each section of the basic instrument.

Analog or Digital

At one time, you could get used, even new, analog meters at a reasonable price. Now, you can find new, digital panel meters at highly competitive prices. You can buy new digital multimeters for less than the price of a basic analog meter movement. So, the decision to use A or D for your readout may be

PHOTO D. Digital light meter. Reading the light level for its own photo.



determined in part by what you have available. The light meters described here will work with either by making suitable adjustments to some of the circuit values.

As in the case of the ultra simple system, you can clip either type of ohmmeter to the photo cell and have a working light meter. You may note some differences in the resistance of the CdS cell when reading the same light source, but using first an analog meter, and then taking a reading with a digital ohmmeter. Just use the same meter for all of the readings on your calibration chart.

Figures 7 and 8 show two versions of a simple, practical light meter. One uses an analog readout, the other uses a digital display. The simplest one uses the analog meter.

An Analog Light Meter for Ambient Light

This instrument (Figure 7) has two ranges and uses a regulated power supply. A common 7805, and a nine-volt battery make up the power supply, noth-

Continued on page 84

"We knew the storm was coming before the Park Rangers did"

All Hazards Weather Radio provides continual weather and emergency monitoring and has a variety of helpful features.

by C. Eddie Vernon

On a recent camping trip, a friend of mine brought along a portable radio he'd received as a gift. Supposedly, it would pick up weather information and broadcasts from the U.S. Emergency Alert System. He brought it along for fun…little did we know how lucky we would be to have it. After we had set out into the woods, a storm system moved into the area, bringing with it a possibility for severe tornadoes. When the red Alert light came on and the loud warning tone sounded, we looked at each other, shrugged and decided to return to the Park Ranger's cabin. Later that night, tornadoes hit the area in which we'd planned to camp. Who knows what would have happened if we hadn't been warned, but one thing is for sure—now I don't go anywhere without my All Hazards Weather Radio.

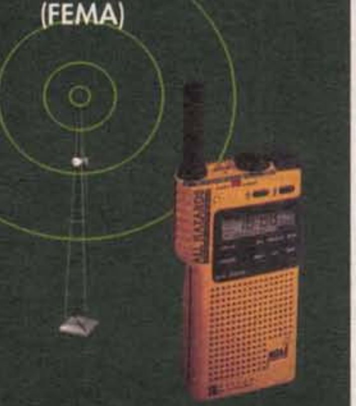
Lifesaving information. Until now, there has been no single source for immediate, comprehensive weather and emergency information, available to the public, in advance of TV and radio bulletins. Oregon Scientific, a leader in personal electronics, has created a special radio that is ideal for traveling, as well as for campers, hikers and everyone who needs to be prepared for weather emergencies in the great outdoors. It monitors the U.S. Emergency Alert System and automatically seeks all seven frequencies used by the NOAA (National Oceanic and Atmospheric Administration) Weather Radio system. This network broadcasts 24-hour weather forecasts, weather-related travel conditions and warnings about imminent severe weather conditions.

Automatic alert. In the event of special warning broadcasts, the radio's innovative alert system automatically activates a loud tone and a flashing red LED indicator. If the radio is in silent standby mode, it even turns on the speaker. Emergency bulletins might include alerts for tornadoes, hurricanes, earthquakes, ice and snow storms, thunderstorms and other severe weather. Bulletins also cover toxic chemical incidents, oil spills, radiation conditions, hazardous explosions and fires and other emergencies that require immediate public notification. Messages dealing with the aftermath of disasters, such as recovery and relief efforts, will also be broadcast.

Important features. The radio incorporates a variety of special features geared to outdoor use. These include a built-in analog compass, ambient temperature display and an audible/ visual Freeze Warning Alert. The digital display incorporates a clock with alarm and snooze controls. A switch lets you turn the speaker to ON or MUTE, or you can set the unit to stand-by mode. The unit's water-resistant case is rugged and durable, and there's even a built-in belt clip and desktop stand. Its compact, lightweight design makes it ideal for almost any situation, and it operates on 3-AA batteries.

UPDATES AROUND THE CLOCK

- NOAA Weather Radio Network
- U.S. Emergency Alert System
- Federal Emergency Management Agency (FEMA)



Don't leave home without it. The portable All Hazards Weather Radio was named a winner of the "Innovations" Design and Engineering Award at the 1998 Winter Consumer Electronics Show. This prestigious annual international competition honors outstanding product design achievements. This remarkable new product makes use of the latest technological advances, and it's ideal for use while traveling in cars, recreational vehicles and boats. Campers, fishers, hunters, hikers, skiers, golfers and any other outdoor enthusiasts can benefit from this amazing new technology.

> "Special emphasis will be placed on getting these radios installed in every home, just like a smoke detector, and in all schools, hospitals and other public gathering places. It'll give people the kind of information they need to safeguard themselves and their homes during a disaster."
>
> *—Vice President Al Gore, speaking in support of the new Emergency Alert/NOAA Weather Radio system.*

Try it risk-free. The All Hazards Weather Radio can make any outdoor activity safer and more enjoyable. It comes with a one-year manufacturer's limited warranty and Comtrad's exclusive risk-free home trial. If for any reason you are not satisfied, simply return it within 90 days for a full "No Questions Asked" refund.

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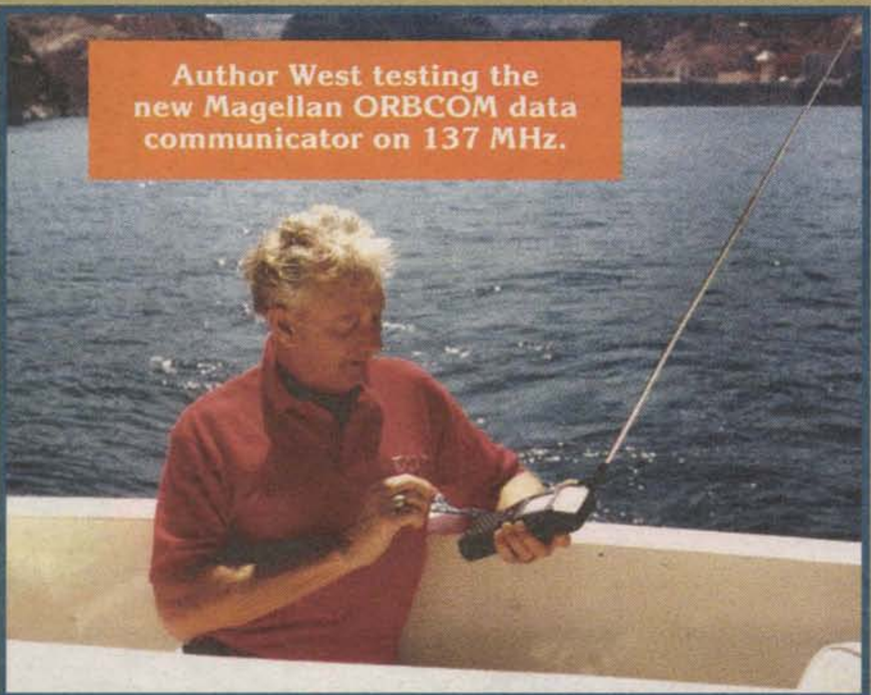
E-MAILING FROM 3 MHz-30 MHz

by Gordon West

Sending short packets of E-Mail over the airwaves is commonplace on VHF and UHF frequencies, 30 MHz to 2,500 MHz. Alphanumeric pagers are one form of E-Mail wireless reception. FM broadcast stations may send sub-carrier access (SCA) continuous E-Mail messages to paid subscribers. Home satellite TV receivers are bombarded with audio, video, and text E-Mail messages. The transmission of E-Mail from satellites and terrestrial stations to portable, mobile, and fixed receivers is commonplace.


Author West testing the new Magellan ORBCOM data communicator on 137 MHz.

Transmitting E-Mail messages back is relatively common on VHF, UHF, and microwave frequencies. Delivery trucks and police departments have been doing it for years. Cellular telephone E-Mail connections are commonplace throughout most of the US.

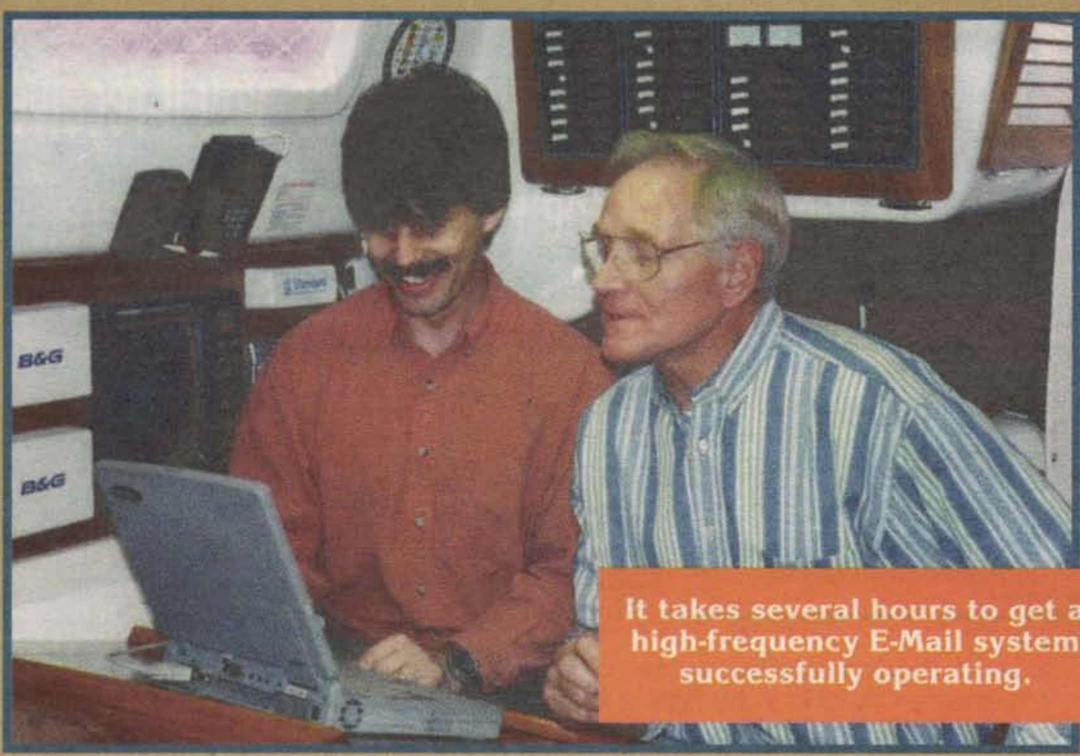
If you're not on a budget, you can return E-Mail communications through a variety of geostationary satellites with spot-beam coverage. It's these spot-beams from the geos that may constantly keep track of E-Mail responses to motor carriers or sailors 100 miles off shore.

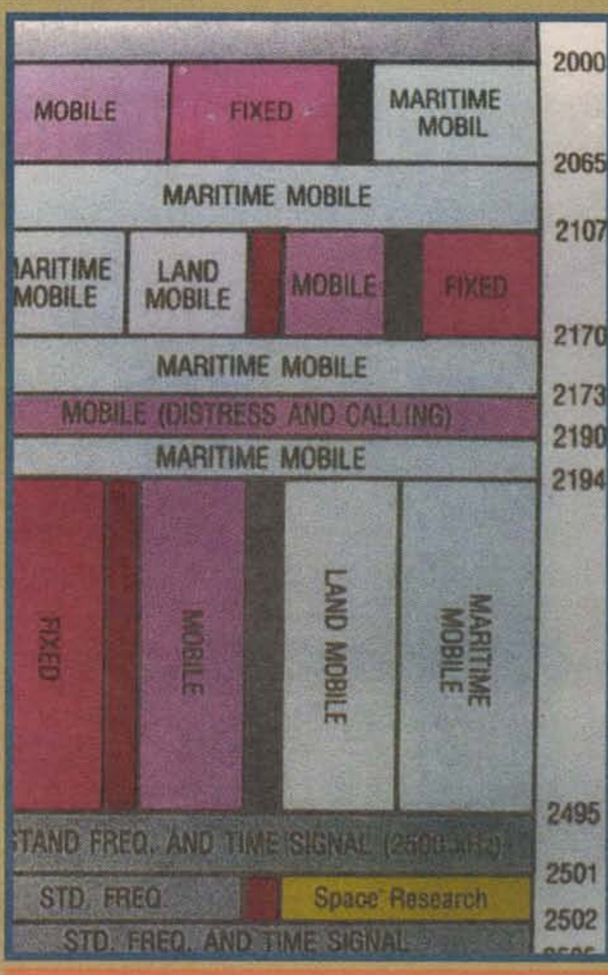
There are also four total coverage INMARSATs for those mariners that go beyond spot-beam coverage and need to receive and transmit back E-Mail communications. It takes a bigger shipboard antenna to get back to the satellites for worldwide coverage.

And soon we will be blanketed by hundreds of low-earth-orbit satellites providing anywhere E-Mail communications. In another two years, you can take your laptop anywhere in the world and download and upload E-Mail messages just like you do at home plugged into the phone line. Anywhere — but, of course, you'll need to be outside where your computer transmitter/receiver has an unobstructed shot at the sky. Low-earth-orbit E-Mail satellites — such as ORBCOM — work quite nicely to a yard-long telescopic whip that is attached to your wireless computer radio system.

OLD HAT ON HF

Radio frequencies from 3 MHz to 30 MHz have been the stomping grounds for wireless E-Mailers over the past 30 years. Ham radio ops started E-Mail with Model 45 radio teleprinters hooked into their HF worldwide transceivers. Data was bounced off of the ionosphere quite suc-


It takes several hours to get a high-frequency E-Mail system successfully operating.



There are plenty of open frequencies for high-frequency E-Mail connections.

cessfully. Commercial shipping and bigger yachts also had early wireless E-Mail capabilities — called radio telex. They, too, would rely on the F-layer of the ionosphere to refract their data signals back down to a companion station thousands of miles away.

While some hams and boaters have abandoned their long wires and big antenna systems for pay-per-airtime compact satellite stations, their abandonment of the high-frequency bands has opened up a gateway of marine and ham shore-side E-Mail gateway stations, all tuned in and ready to transmit and receive the distant skywave call. And many of these operators can send and receive E-Mail, off of the ionosphere, absolutely free!

But not ALL E-Mail shore stations serving wireless operators all over the world may offer their service for free. Powerful commercial marine coast stations like Globe Wireless in California; Mobile Marine in Mobile, AL; and PinOak in New Jersey indeed charge a monthly fee for their high-frequency E-Mail service, plus possible additional charges if you exceed the amount of allocated characters you are sending or receiving.

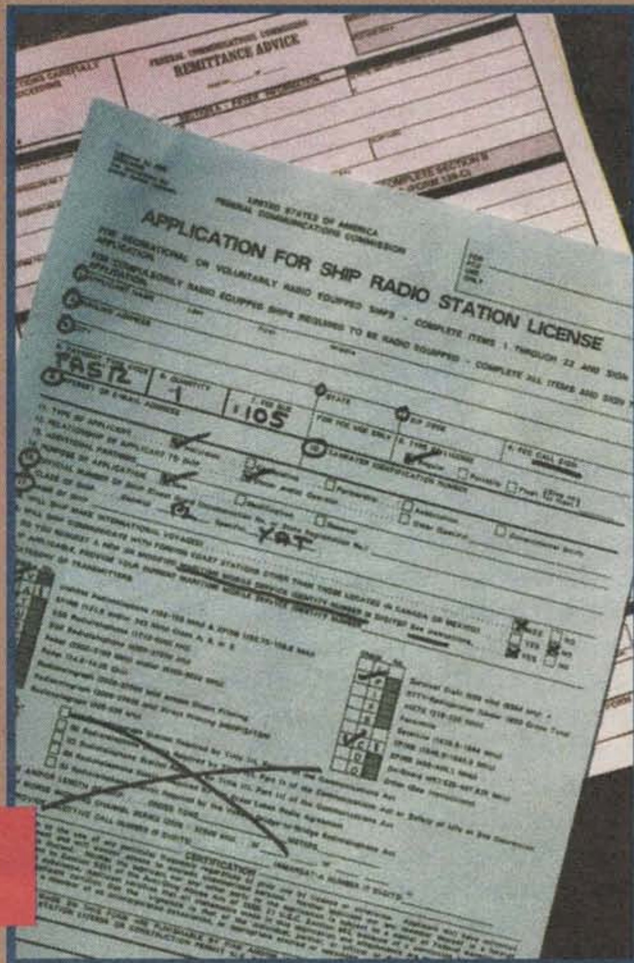
Most commercial E-Mail high-frequency sign-ups run about $40.00 a month which includes plenty of uploads and downloads.

If you regularly do a lot of E-Mail, and if you do it out on the water or in remote areas not served by land lines or cellular phone, commercial E-Mail to these state-side megawatt stations is a pretty good deal. No license test is required, but your equipment must meet specific FCC type-acceptance for Part 80.

ALMOST FREE

If you do your remote or boating thing in just one part of the country, several non-profit "private coast stations" are coming on-line to handle your wireless high-frequency E-Mail. These private coast stations may not have near the coverage or radio system that the commercial boys have, but for under $100.00 a year, they might serve you well with absolutely no additional charges for long-winded keyboarding nor any restriction on what type of messages you are sending over the airwaves.

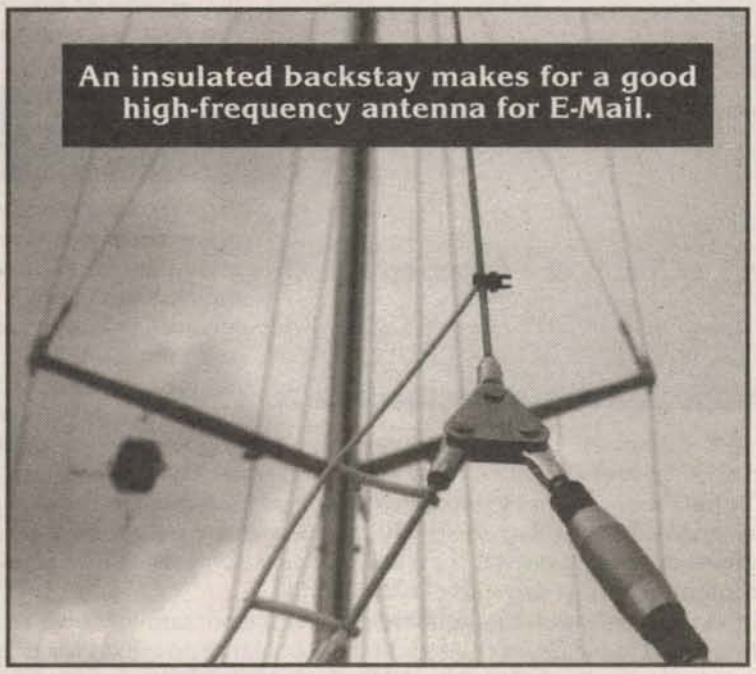
The group that started this almost-free E-Mail service is called Sail Mail out of Palo Alto, CA. It's like a volunteer organization that specializes in over-the-water messaging. These private coast stations



Boaters must fill out an FCC license application before going on the air with E-Mail on 3 MHz-30 MHz.

usually reach out for several thousand miles, and data is transferred at a rate between 10 and 60 characters per second.

I know this sounds horribly slow, but keep in mind that there is no air-time charge and your radio and computer are doing all the work after you have composed your mail ahead of time before switching on the transmitter.



An insulated backstay makes for a good high-frequency antenna for E-Mail.

INMARSAT M Geo satellite antenna system on a powerboat.

FREE WITH A LITTLE TEST

Amateur radio operators are the pioneers of the airwaves. Between hams and the military, they STARTED data wireless. The ham radio system is called AIR MAIL, and there are ham-radio-operator run Air Mail sites all over the world.

Each ham station may monitor as few as one, or as many as 17 different frequencies, hoping that other licensed US and foreign hams all over the world will take advantage of their free service. Similar to Sail Mail, the ham E-Mail connection is at a data rate between 10 and 60 characters per second.

Yup, it's like watching paint dry, but the ham would compose the mail rapidly ahead of time, load it into a buffer, hit the send button, and let the radio and computer do the rest.

But the ham system has one important restriction — ABSOLUTELY NO COMMERCIAL BUSINESS ON HAM BANDS. Now that doesn't mean you must only communicate about non-important silly things — it is perfectly okay to E-Mail for parts, reservations, important documents, and things like this that pertain to the ham operator or those around him. But E-Mailing to the office, or conducting business on E-Mail for profit, is not allowed on ham Air Mail.

Also, high-frequency ham band operation requires passing the General class ham license test. And test passing for hams takes a little dedication — 30 days of pounding the books, and then a little bit of Morse Code.

The General class Morse Code test is soon to become a great deal easier — the Federal Communications Commission has proposed dropping the present 13 wpm requirement down to a simple 5 wpm comprehension code test.

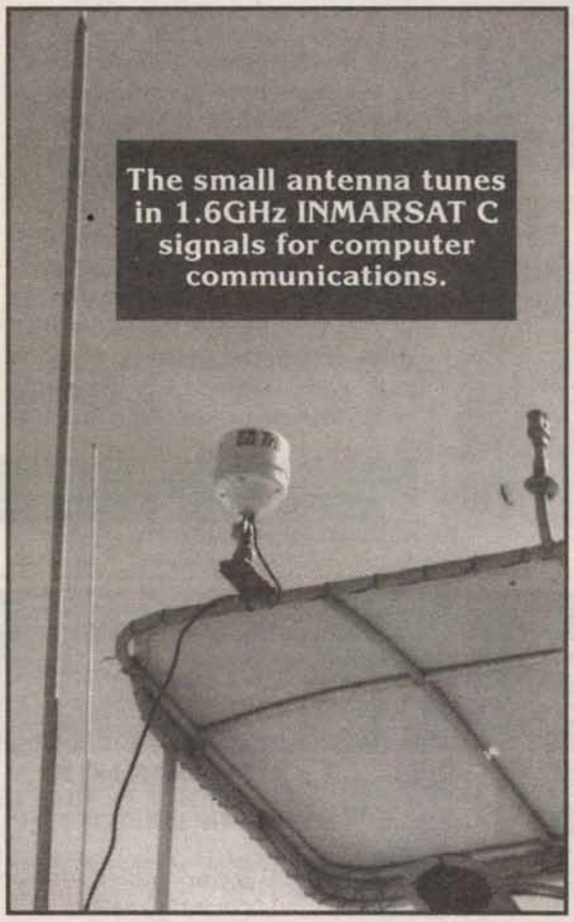
This will remove one of the biggest obstacles to General class high-frequency operation by technical people like *Nuts & Volts* readers who had no problem getting through the theory, but didn't have the time or determination to spend mastering the dots and dashes.

THE EQUIPMENT

For worldwide high-frequency data communications, you will need a high-frequency transceiver that might be a ham set or a Part 80 type-accepted marine SSB.

You will need an antenna system that could be as simple as two pieces of one-quarter wavelength wire strung between two poles and fed to your radio with common coax. You will need your laptop, and you may or may not need a terminal node controller.

A ham out of San Clemente, CA, John Hoot, has perfected a software program along with his patented analog-to-digital plug assembly to run a program that transmits and receives digital modes with absolutely no terminal node controller required (Software Systems Consulting, San Clemente, CA; 949-498-5784).



The small antenna tunes in 1.6GHz INMARSAT C signals for computer communications.

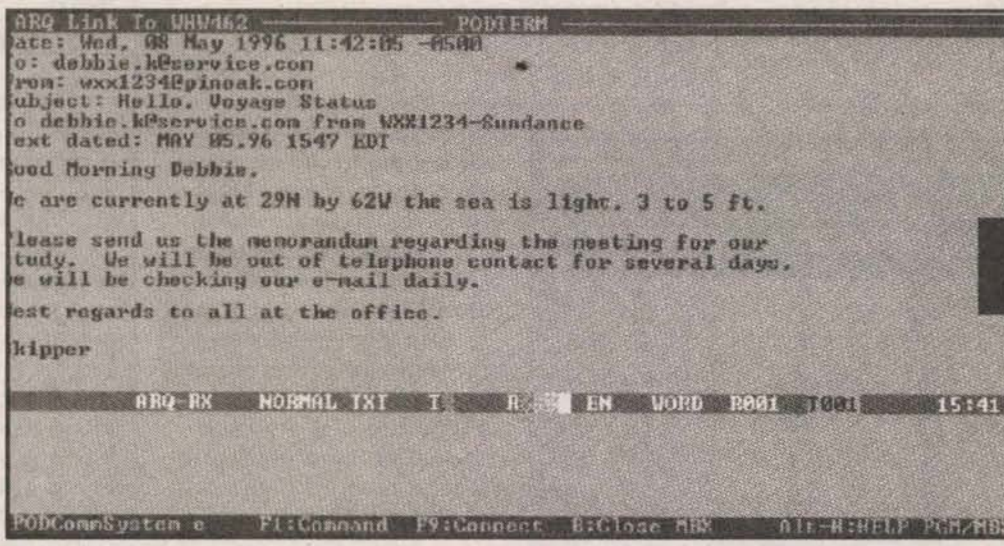
John and his wife continue to amaze the data industry by coming up with smarter and smarter software that may take the job of the hard-working terminal node controller. But I must say, when conditions get rough, terminal node controllers like Kantronics can really pull signals out of the noise. And the most amazing TNCs come from Hal and SCS that can extract data signals from what sounds like nothing but hash coming out of the speaker!

Some of the best software to support these radio data modes is written by Jim Corenman, an avid yachtsman. It is freeware and available on the Internet.

Look at www.sailmail.com/mprimer.htm. Pay attention to the section on performance and PROBLEMS. "Coming up on high-frequency radio and sending successful E-Mail is not a plug-and-play operation," comments Julian Frost N3JF, an HF E-Mail installer and problem-solver (Costa Mesa, CA; 949-646-6567).

"Any computer located within a few feet of the radiating antenna may get saturated from the strong radio frequency near-field and distort the outgoing datastream," adds Frost.

This leads to a no-connect at the other station ecause all it hears is a distorted transmit signal.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ARQ Link To WHW462 ─────────── PODTERM ───────────
Date: Wed, 08 May 1996 11:42:05 -0500
To: debbie.k@service.com
From: wxx1234@pinoak.com
Subject: Hello, Voyage Status
To debbie.k@service.com from WXX1234-Sundance
Text dated: MAY 05.96 1547 EDT

Good Morning Debbie.

We are currently at 29N by 62W the sea is light. 3 to 5 ft.

Please send us the memorandum regarding the meeting for our
study.  We will be out of telephone contact for several days.
We will be checking our e-mail daily.

Best regards to all at the office.

Skipper

      ARQ-RX    NORMAL TXT    I      R     EN    WORD  R001  T001      15:41

PODCommSystem e    F1:Command  F9:Connect  B:Close MBX     Alt-H:HELP PGM/MBX
```

Typical E-Mail message.

"Your same computer can also generate severe interference to the high-frequency receiver, masking weak incoming E-Mail responses," advises Frost. "Sometimes the older and slower 486 laptop computers running Windows 95 are better suited to HF E-Mail operation than the newer, faster Pentium 233 system," adds Frost. But once you get your E-Mail high-frequency radio system up and running with a successful exchange to a distant base station, chances are you are set for a low-cost and sometimes free gateway to the Internet, almost anywhere in the world.

The ionosphere won't be affected by any millennium hiccups, so high-frequency E-Mail is now becoming a popular proposition for those radio operators wanting the ultimate back-up to satellites and land-line E-Mail servers.

Ultimately, satellite E-Mail handheld transponders may become the most popular way of staying in touch, but there will still be high-frequency E-Mail communications by those who want to save money and enjoy the art of bouncing signals off of the ionosphere. **NV**

reader FeedBack

Dear Nuts & Volts:

Congratulations on a wonderful 20 years! I've been around since the start and have been amazed at your "something for everybody" content. Keep the same balance of technical articles going and you can run forever.

Barry Collins
Demopolis, AL

Dear Nuts & Volts:

In the article about magnifiers the Internet address for the Microscope Society of America should be www.msa.microscopy.com and not www.msamicroscopy.com.

I love your magazine, I can always count on each issue to have something of interest that is almost impossible to find anywhere else.

Anthony L. Zaccardi
via Internet

Dear Nuts & Volts:

The article on Elcad (Feb. '99 issue), was very well done. Fred Blechman did a very outstanding job. I have received a lot of orders already.

I've had many calls, though, because they are not sure of the price. In the article, the price is stated as $14.95, but at the end in the SOURCE, it is stated as $10.00. The $10.00 price is the correct one.

Also, the E-Mail address is not completely correct. As you can see it is bellis350@aol.com.

Thank you for running this article.

Brian Ellis
via Internet

Dear Nuts & Volts:

I enjoyed the article "Recovery and Refining of Gold from Scrap Electronics" by Michael E. Young. I appreciate the emphasis that Mr. Young places on safety with a whole section devoted to the topic. However, he omitted a very important safety procedure.

In Mr. Young's article, he explains the process of mixing the acids and gold removal. When this process is complete, he tells the readers to "Add 100ml of distilled water to the solution from step 2." I have to assume that step 2 is the acid mixture. This is a potentially hazardous operation.

Adding water to acid is a sure way to have acid spattered over the work surface or worse, personnel. The acid reacts with the water and can instantly heat it beyond its boiling point. This can cause a small steam explosion, thus splashing the acid.

The rule is always "Acid into Water" never the reverse. I sincerely hope that readers that attempt this gold recovery procedure are aware of this rule.

C. Eric Chesak
El Paso, TX

Dear Nuts & Volts:

I thought your readers would be interested in knowing that the "Lightning Observing" circuit configuration described in your Feb. '99 Open Channel column appears on page 885 of *Radio Engineers Handbook*, by F. E. Terman, McGraw-Hill, 1943 ed.

I designed a lightning locator in 1953 based on the description in Terman's book using X, Y, and Z axis channels. The lightning locator was manufactured by Radio Specialists Co., Denver, CO, for professional cloud seeders and was used world-wide.

The lightning locator helped identify moisture laden clouds which had the potential for delivering substantial rainfall when seeded with silver iodide crystals.

William C. Zarnstorff
Madison, WI

Dear Nuts & Volts:

There are lots of people across the country that own all sorts of older, used, army test equipment, tube testers, scopes, signal generators, etc., and very few people know where to look for a service manual.

Here are the addresses of two places where these manuals are stored at:

1. Dept. of the Army: US Army Military History Institute, Attention: Historical Reference Branch, Carlisle Barracks, Bldg. 22, Carlisle, PA 17013-5008. Phone 717-245-3611, fax 717-245-3711, DSN 717-242-3611.

2. Center for Legislative Archives, National Archives, and Records Administration, 8th St. and Pennsylvania Ave., N.W., Washington, DC 20408.

Kenneth L. Mixon
Perry, FL

Write in 102 on Reader Service Card.

Data Logging with a Digital Multimeter and Your PC

by Fred Blechman

There is a "new breed" of digital multimeter (DMM) on the market — one that does "data logging" using your computer. What is data logging? Normally, what you see on the LCD display of a DMM is updated several times a second, so changing readings are "lost." Data logging provides a means of capturing these readings, using an RS-232 computer interface, and displaying and holding them for future analysis. It can replace an expensive strip recorder. Several manufacturers now offer data logging DMMs (see "Sources"). This article will cover a typical unit in detail. Others are similar, but with varying specifications.

If you have the need to monitor slowly changing electrical measurements for periods of minutes to days, and you have an IBM compatible personal computer, you'll want to know about the Elenco M-6100 Digital Multimeter with Computer Interface. Costing only $99.00, it is one of several under-$100.00 data logging multimeters, a relatively new class of digital multimeters.

The purpose of this report is to describe the features and operation of this type of DMM in sufficient detail for you to determine how one might fit your needs. We'll tell you about the many special features of this digital multimeter (DMM) that distinguish it from typical DMMs, and will then describe its use with a computer.

Digital Multimeters

Digital multimeters have been available for many years, but originally were quite expensive compared to tried and true needle-reading analog meters. But prices have come down so drastically for basic DMMs (we've seen them for under $15.00!) that they are now far more commonly used than analog multimeters. Also, DMMs have much higher input impedances than analog meters, so they are far less likely to disturb operation of a circuit under test.

Typically using liquid crystal display (LCD) readouts, the least expensive DMMs measure DC or AC voltage and resistance, and most also measure DC current, within several discrete scale ranges. Better DMMs add higher ranges and additional functions like diode tests, transistor gain, and a continuity buzzer. The more deluxe (and expensive) DMMs measure frequency, capacitance, and inductance within limited ranges.

Some DMMs use "auto-ranging." Instead of having to select a range, an auto-ranging DMM starts from the top range and automatically steps down to the proper range. This saves you the trouble of determining the proper range for the measurement being taken, and may save the meter from an unintentional overload on too low a range selection.

The Elenco M-6100

Although it does not test transistor gain or inductance, the auto-ranging Elenco M-6100

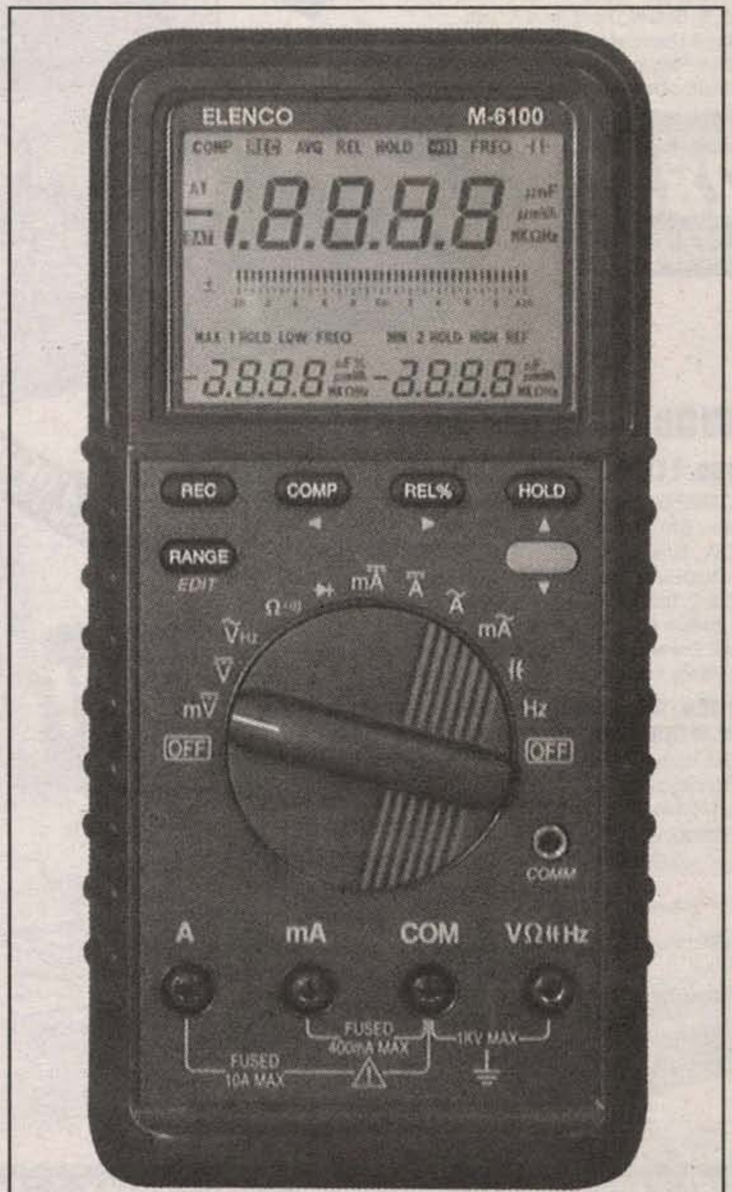

Figure 1 - The Elenco M-6100 Digital Multimeter is auto-ranging, and has special buttons for functions described in this article.

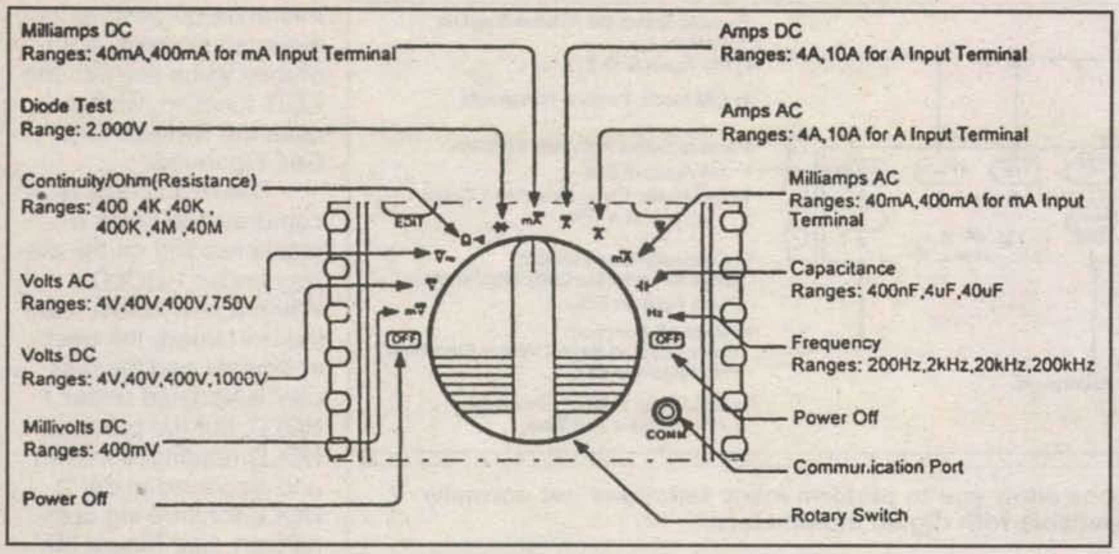

Figure 2 - Rotary switch functions and ranges.

does all the other tests mentioned above, plus several additional functions not found on most DMMs, including "data logging."

What is data logging? Normally, what you see on the LCD display of a DMM is updated several times a second, so changing readings are "lost." Data logging provides a means of capturing these readings and holding them for future analysis. The M-6100 does this by sending the data stream through an RS-232C serial interface cable to your IBM-compatible personal computer, where it is displayed and graphed, and can be printed or saved in a disk file.

Features

As seen in the Figure 1 photo, the Elenco M-6100 has a large multi-function LCD screen, evidence of the many features and functions of the M-6100.

It can capture Maximum (MAX), Minimum (MIN), and Average (AVG) values simultaneously on the LCD. In-tolerance limits can be set, and PASS is displayed in large digits when the reading is in tolerance, LO when below, and HI when above.

A relative % (REL) measures the percentage of tolerance on the input signal with respect to a reference (REF) value. A three-hold system captures and holds a newly updated stable reading on the main display, and also shows the previous and last stable readings as 1 HOLD and 2 HOLD on the smaller digits.

The AC measurement also measures frequency at the same time. A 41-position analog bar display and pointer graphs the input signal value.

But what you don't see in the photo are some of the behind-the-scenes features of the M-6100.

The M-6100 measures the true RMS (root mean square) value of AC voltage and current. This is a unique feature for non-sinusoidal waveforms.

A standard 9V battery is used, and the display shows when the battery is low. An automatic power-off function extends battery life. If, for 30 minutes, the rotary switch is not moved, or any push button pushed, the power goes off; turn the switch or push a button and the meter comes back on. You can defeat this if you choose, thus letting the power stay on for extended periods of data collection for over eight days on the 9V internal battery — or longer with external power.

The 3.5-inch wide by 7.44-inch high by 1.22-inch thick M-6100 comes in a rugged case to protect it from rough handling, and includes an integral swing-out tilt stand. Everything is provided: 32-page illustrated Operating Instructions; RS-232C communication cable; red and black test probes; installed battery; and software diskette for Windows 3.1.

The M-6100 operates out-of-the-box as an auto-ranging DMM with the following specifications (see Table 1 for details):

- DC voltage to 1000 volts in five ranges
- AC voltage to 750 volts in four ranges
- DC current to 10 amps in four ranges
- AC current to 10 amps in four ranges
- Resistance to 40 megohms in five ranges
- Capacitance to 40 microFarads in three ranges
- Frequency to 200 KiloHertz in four ranges
- Continuity buzzer
- Diode test

If you choose to do data logging, you'll need a computer with the following minimum requirements: IBM PC/XT/AT (8088, 80286, 80386, 80486, Pentium, or compatible); RS-232C serial port; and Microsoft Windows Version 3.1 or better.

Note that the software provided is NOT a DOS program. However, a simple QuickBASIC/QBASIC program (Listing 1) will provide data logging to the screen, and (with a slight change) to the printer. More on that later.

Switch Functions

Figure 2 shows the functions and ranges available with each rotary switch position. By simply putting the switch in any of the positions shown (except OFF),

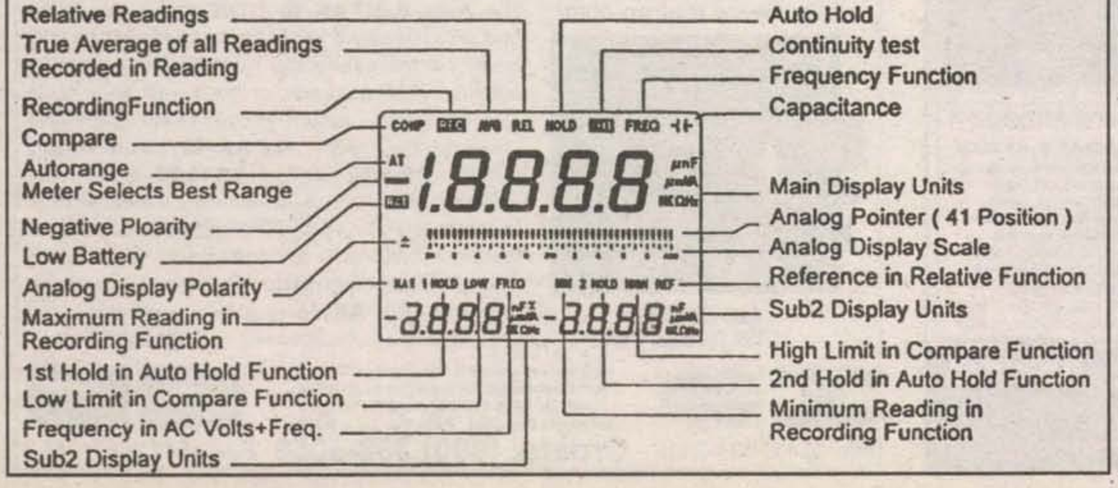

Figure 3 - The large LCD display shows many readings, including an analog display.

the meter is turned on and starts attempting to read the input signal. Of course, the meter probes must be connected to the circuit under test. If the signal is a DC signal and the polarity is reversed, the display will show a minus sign.

Unless the meter is put in the Manual Range mode by pressing the RANGE key, it automatically seeks the optimum range for the measurement being made. If the measurement goes above or below the initially selected range, it automatically changes to the proper range.

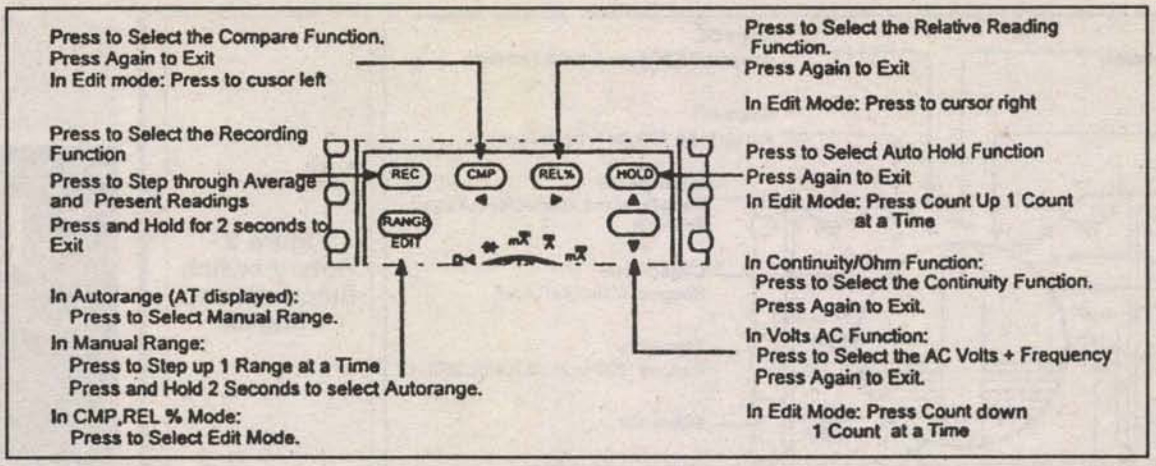

Figure 4 - Six push buttons allow you to perform many functions not normally available with digital multimeters.

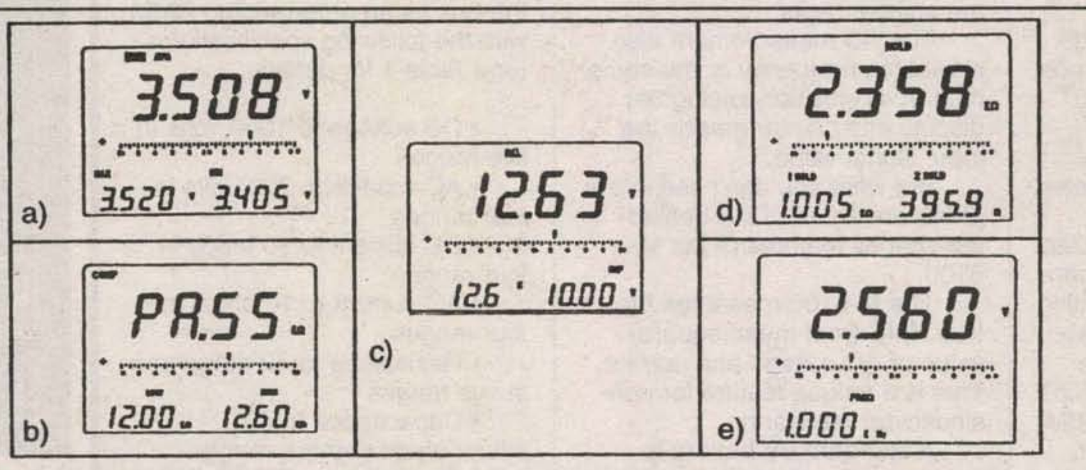

Figure 5 - M-6100 displays: (A) RECORD button; (B) COMPARE button; (C) REL% button; (D) HOLD button; (E) YELLOW button. See text for explanations.

Display and Push Buttons

Figure 3 shows the large (2.3-inches wide by 1.7-inches high) LCD display. The largest digits, .45-inches inches high, read a maximum of 19999, so this is considered a 4-1/2 digit meter. (Most inexpensive DMMs are 3-1/2 digits.) The lower "secondary" digits are .22-inches high.

Figure 4 shows the six push buttons just below the display, and their purpose. Figure 5 shows the displays associated with these push buttons.

The REC (Record) push button captures and displays maximum (MAX) and minimum (MIN) values simultaneously on the secondary display in the lower part of the LCD, as shown in Figure 5A. If you push the REC button again, the meter calculates and displays average (AVG) in the main part of the LCD, together with the MAX and MIN readings.

The COMP (Compare) button verifies whether the input signal is within the tolerance limits set by the EDIT function, which uses the RANGE key. PASS is displayed for an in-tolerance signal, HI is displayed for a signal above the set range, and LO for a signal below the set range. The tolerance limits are displayed on the secondary lower display. See Figure 5B.

The REL % (Relative Percent) button enables you to measure the out-of-tolerance percentage of the input signal to a reference value set with the EDIT function, which uses the RANGE key. See Figure 5C.

The HOLD button captures and holds a stable reading on the display under 1 HOLD. When a new stable reading is entered, the beeper sounds and the display is updated under 1 HOLD, but the previous HOLD reading is moved and displayed under 2 HOLD for time-lag comparison. See Figure 5D.

When measuring AC voltage, if you press the YELLOW button, the frequency of the AC signal will also be shown in the secondary display, as shown in Figure 5E.

The RANGE button is used in the COMP mode to EDIT the HIGH/LOW limits, and in the REL % mode to set the reference value. The arrow symbols below the COMP, REL %, HOLD, and YELLOW buttons are

Listing 1 - QuickBASIC/QBASIC program for DOS data logging to screen. Change PRINT to LPRINT for printer output.

```
        CLS
        GOSUB ComOpen
        ON COM(2)  GOSUB GetCom
        COM(2)  ON
WaitLoop:
        GOTO WaitLoop

ComOpen:
        CLOSE #1
        OPEN  "com2:1200,n,7,1,rs,cs,ds,cd"  FOR RANDOM AS #1
        RETURN

GetCom:
        COM(2)  OFF
        INPUT #1,  rd$
        IF LEN(rd$)  >  9 THEN
                RdgData$  =  RIGHT$(rd$,  7)
                FunCode$  =  LEFT$(rd$,  1)
                ModCode$  =  MID$(rd$,  2,  1)
                RgeCode$  =  MID$(rd$,  3,  1)
                PRINT FunCode$;  "  "; ModCode$;  "  "; RgeCode$;  "  "; RdgData$
        END IF
        COM(2) ON
        RETURN
```

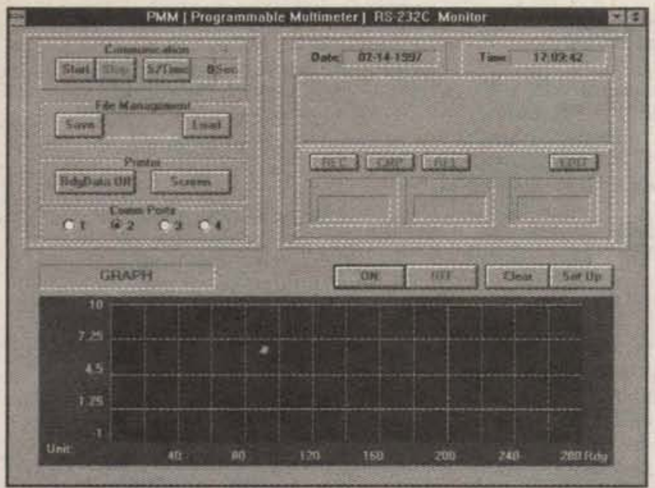

Figure 7 - Windows 3.1 screen with no data.

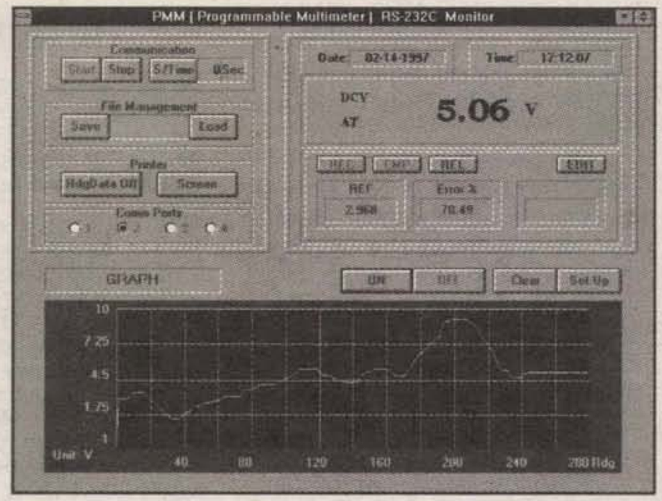

Figure 8 - Windows 3.1 screen with some data.

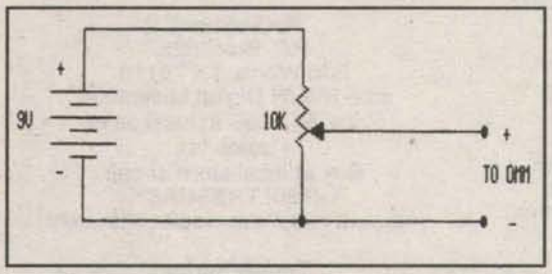

Figure 6 - Simple setup to test the DC voltage ranges on any multimeter with a 9V battery and potentiometer.

used in the EDIT mode to set values, as described in the M-6100 Operating Instructions. Not mentioned in the Instructions is the fact that you must, after setting the limits or reference value, press RANGE again for readings to begin.

Using the push buttons is easier than explaining them. Their action is shown on the display. While the display shows many functions and indicators, and seems confusing, they all make sense when used with the push buttons.

Using the Elenco M-6100 as a DMM

In order to get familiar with the many functions of the M-6100, we used a simple circuit to provide varying DC voltage, as shown in Figure 6. This is nothing more than a 9V battery across a potentiometer, with the voltage to the M-6100 taken from the potentiometer wiper to battery negative.

The value of the potentiometer is not critical, but the 10K value shown draws less than 1 milliampere of current from the battery. A potentiometer value of 100K, 500K, or even 1 megohm could be used.

With the positive and negative output of this circuit connected to the multimeter, the voltage displayed will vary with the rotation of the potentiometer shaft. At one end of the rotation the voltage will read battery voltage; at the other end it should read zero. By simply turning the potentiometer shaft, you vary the voltage, and thus can test the various push button functions.

An audio signal generator can be used to test the AC functions, including the frequency counter function of the M-6100. Capacitors, diodes, and continuity can be tested directly. The Operating Instructions show illustrations of the meter probe connections and rotary switch positions for the various functions.

Using the Elenco M-6100 for Data Logging

While the M-6100 display shows the various readouts, it takes a computer to save this information — data logging. Your IBM compatible computer must have the minimum requirements listed earlier.

The RS232C interface cable supplied with the M-6100 has a standard miniature phone plug that fits into a jack on the front of the DMM. The other end of the cable terminates in a DB-9 connector. If your computer serial port uses a DB-25 connector, you'll need a commonly-available 9-25 pin adapter.

The M-6100 Operating Instructions provide a short program (Listing 1) that you can use with QuickBASIC or QBASIC for limited data logging to the screen. Change PRINT to LPRINT and the data will go to your printer.

However, interpretation of this data format involves decoding function and range codes, explained in the Operating Instructions. If you decide to try this, make sure your serial port is set to 1200 baud, no parity, 7 data bits, and 1 stop bit.

You are MUCH better off using the included diskette with Microsoft Windows. An instruction sheet provided with the diskette covers the installation and use of the software, and the function of each of the screen "buttons."

DC VOLTAGE		Resolution	100pF, 1nF, 10nF
Range	400mV, 4V, 40V, 400V, 1000V	Accuracy	±0.05% + 5d
Resolution	100µV, 1mV, 10mV, 100mV, 1V	**FREQUENCY**	
Accuracy	±0.3% + 2d	Range	200, 2KHz, 20KHz, 200KHz
AC VOLTAGE		Resolution	0.01Hz, 0.1Hz, 1Hz, 10Hz
Range	4V, 40V, 400V, 1000V	Accuracy	±0.05% + 5d
Resolution	1mV, 10mV, 100mV, 1V	**Audible Continuity**	Threshold: Approx 100Ω
Accuracy	±0.5% + 5d	**Diode Test**	Test Current: 1mA Open circuit Voltage: 3V
DC CURRENT			
Range	40mA, 400mA, 4A, 10A	**General**	
Resolution	10µA, 100µA, 1mA, 10mA	Power Requirements	Single 9V battery (NEDA 1604 or 6F22 or 006P)
Accuracy	±0.5% + 5d		
RESISTANCE		Fuse	0.5A/250V fast acting and 10A/250V
Range	400Ω, 4KΩ, 40KΩ, 400KΩ, 4MΩ, 40MΩ		
Resolution	0.1Ω, 1Ω, 10Ω, 100Ω, 1KΩ, 10KΩ	Sampling Rate	20 times/Sec nominal
Accuracy	±0.3% + 5d	Battery Life	250 hours typical
CAPACITANCE		Dimensions	7.45" (H) x 3.59" (W) x 1.26" (D)
Range	400mF, 4µF, 40µF	Weight (Meter Only)	11.3 oz.

Table 1 - Elenco M-6100 Specifications

Installation is fast and straightforward, and the single multi-window screen display is easy to read and use.

Figure 7 shows the screen with no input signal. Notice the graphical portion, which is like a strip chart. Strip recorders are expensive. An electrocardiograph (EKG or ECG) machine for measuring heart action is an example of a strip recorder. Other examples of strip recorders are lie detectors and earthquake recorders. Most strip recorders use an inked or thermal stylus with analog meter-like action leaving a track on moving paper. The M-6100 graphical display can be printed out, simulating a strip recorder at far less expense.

The screen graph X and Y coordinates can be easily changed. The number of samples on the horizontal X axis of the graph can be set to a total of 280, 350, 700, or 1,400 samples. We found no limit to the setting of the vertical Y axis value.

The sampling rate can be varied from .333 seconds to 999 seconds. Using the longest 999-second sampling time, and the maximum of 1,400 samples, it would take over 16 days to complete the screen graph! Although the internal 9V battery is good for only about eight days, you could attach an external 9VDC power supply to the battery snap for longer operation.

We used the test setup described earlier in Figure 6. By randomly rotating the shaft of the potentiometer, the DC input to the M-6100 was varied, and we could see the result on the screen and on the graph. See Figure 8. We could also click on the various screen buttons to test their functions. Everything worked perfectly.

The data being logged can be saved to the printer or a disk file for later analysis. You can also send the complete displayed screen to your Windows-installed laser or inkjet printer for use in reports, brochures, proposals, or fault analysis.

The Bottom Line

If your needs are just to occasionally measure a voltage, current or resistance, get an inexpensive multimeter. However, if you are involved with quality control, incoming inspection, research, experimentation, testing, repair — or just a hobbyist or student with the desire to record data — the DMM-6100 is an amazing instrument at a reasonable price. **NV**

Sources

All data logging DMMs come with software for an IBM-compatible PC (some may also address the Macintosh), and an RS-232 cable may NOT be included, so check before purchase.

C & S Sales
150 W. Carpenter Ave.
Wheeling, IL 60090
Elenco M-6100 Digital Multimeter
Price: $99.00 + 5% shipping.
Sales tax for IL residents.
15-day money back guarantee.
Full factory warranty.
Order: 1-(800) 292-7711
Inquiries: (847) 541-0710
Free 60-page catalog:
1-(800) 445-3201
Fax: (847) 541-9904
Internet:
http://www.elenco.com/cs_sales/

EXTECH Instruments
335 Bear Hill Rd.
Waltham, MA 02451-1016
B383273 Multimeter/Data Acquisition System
Price: $199.00 FOB Waltham.
Sales tax for MA residents
30-day full satisfaction guarantee.
12-month warranty
Phone: (781) 890-7440
(8AM-5PM EST)
Fax: (781) 890-7864
E-Mail: extech@extech.com
Internet: http://www.extech.com

Jameco
1355 Shoreway Rd.
Belmont, CA 94002-4100
METEX ME21 3-1/2 Digit Multimeter with Computer Interface
Price: $59.95 + $5.00 shipping.
Sales tax for CA residents
30-day money back guarantee.
90-day warranty
Order: 1-(800) 831-4242
Customer Service: 1-(800) 536-4316
Fax: 1-(800) 237-6948
E-Mail: info@jameco.com
Internet: http://www.jameco.com

MCM Electronics
650 Congress Park Dr.
Centerville, OH 45459
TENMA 72-6000 RS-23 PCI Digital Multimeter
Price: $89.95 + carrier rate + $2.50 + sales tax
Satisfaction guaranteed ... ALWAYS!
Order: 1-(800) 543-4330
M-F 7AM-9PM, Sat. 9AM-6PM EST
Technical: 1-(800) 824-8324
Fax: 1-(800) 765-6960
Internet:
http://www.mcmelectronics.com

RadioShack
P.O. Box 2625
Fort Worth, TX 76113
#22-168VH Digital Multimeter
Price: $129.99 at local store + sales tax
Buy at local store or call
1-(800) THESHACK
Internet: http://www.radioshack.com

TechAmerica
P.O. Box 1981
Fort Worth, TX 76101-1981
METEX ME-11 Auto/Manual Ranging DMM with PC Interface
(Order #910-4092)
Price: $99.95 + $4.00 shipping.
Sales tax for TX residents
Order: 1-(800) 877-0072
M-F 7AM-11PM; Sat. 9AM-8PM; Sun. 11AM-7PM CST
Fax: 1-(800) 813-0087
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Digital Multimeters

Elenco Model M-1740

$39.95

11 Functions:
- Freq. to 20MHz
- Cap. to 20µF
- AC/DC Voltage
- AC/DC Current
- Beeper
- Diode Test
- Transistor Test
- Meets UL-1244 safety specs.

Model M-2760 - $24.95 (9 functions)

Elenco Model LCR-1810

$99.95

- Capacitance .1pF to 20µF
- Inductance 1µH to 20H
- Resistance .01Ω to 2000MΩ
- Temperature -20°C to 750°C
- DC Volts 0 - 20V
- Frequency up to 15MHz
- Diode/Audible Continuity Test
- Signal Output Function
- 3 1/2 Digit Display

Fluke 87III

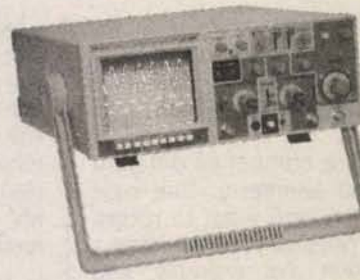
$299

Features high performance AC/DC voltage and current measurement, frequency, duty cycle, resistance, conductance, and capacitance measurement.

Series II (limited qty.) **$289**

Elenco Oscilloscopes

Free Dust Cover and 2 Probes



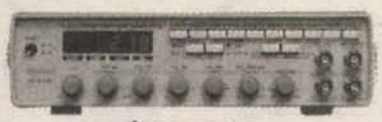
S-1325	25MHz	Dual Trace	$325
S-1330	25MHz	Delayed Sweep	$439
S-1340	40MHz	Dual Trace	$475
S-1345	40MHz	Delayed Sweep	$569
S-1360	60MHz	Delayed Sweep	$749
S-1390	100MHz	Delayed Sweep	$995

DIGITAL SCOPE SUPER SPECIALS

DS-203	20MHz/10Ms/s Analog/Digital	$695
DS-303	40MHz/20Ms/s Analog/Digital	$995
DS-603	60MHz/20Ms/s Analog/Digital	$1295

Generators and Counters

Elenco Sweep Function Generator with built-in frequency counter
Model GF-8036



$225

This sweep function generator with counter is an instrument capable of generating square, triangle, and sine waveforms, and TTL, CMOS pulse over a frequency range from 0.2Hz to 2MHz.

Elenco Handheld Universal Counter 10Hz - 2.8GHz
Model F-2800

$99

Sensitivity:
- <1.5mV @ 100MHz
- <5mV @ 250MHz
- <5mV @ 1GHz
- <100mV @ 2.4GHz

Features 10 digit display, 16 segment and RF signal strength bargraph.
Includes antenna, NiCad battery, and AC adapter.

B&K Frequency Counter
Model BK-1875

.1Hz - 2.8GHz
3 Channels

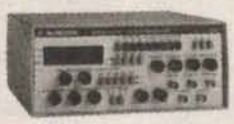
$189

Sensitivity:
- <0.8mV @ 100MHz
- <6mV @ 300MHz
- <7mV @ 1GHz
- <100mV @ 3GHz

Ultra sensitive synchronous detector bargraph and RF strength.

20MHz Sweep / Function Generator with Frequency Counter
Model 4040

$399



- 0.2Hz to 20MHz
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- Burst Operation
- External Frequency counter to 30MHz
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5MHz Model 4011 $239

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Elenco 10Hz - 1MHz Digital Audio Generator
Model SG-9300

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Features built-in 150MHz frequency counter, low distortion and sine/square waves. **SG-9200** (w/o counter) **$119.95**

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$459.95

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Tekk Radios

Pro-Sport FRS Two-Way Radio
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- Removable Antenna
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Model TK-1500

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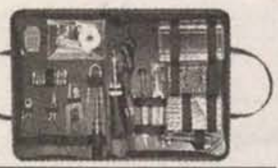

Elenco Quad Power Supply
Model XP-581

$89.95

4 Fully Regulated DC Power Supplies in One Unit
4 DC voltages: 3 fixed - +5V @ 3A, +12V @ 1A, -12V @ 1A
1 Variable - 2.5 - 20V @ 2A

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- Radio Control Included

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$19.95

Model XP-720K **$54.95**

Power Supply Kit
- 1.5VDC - 15VDC @ 1A
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- 5VDC @ 3A
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Digital / Analog Trainer
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Open Channel

by Joseph J. Carr

Radio Telemetry on a Budget

Radio telemetry is the means for transmitting data from the point of collection to a point where it can be recorded, analyzed, and stored.

There are a number of different uses for radio telemetry. One case might be where you want to record one or more physical parameters at a remote location. For example, you might want to record the ultraviolet content of the sun light, the temperature, or seismic activity. You could use a digital data logger or a strip chart recorder with an endless paper supply, and come to the site periodically to collect data. But do you really want to do that? And, if there are numerous sites, the chore might be difficult or even impossibly expensive.

Another use is to track animals in the wild. A beastie is captured and fitted with a radio transmitter. In this case, the data sought might be the location of the animal so the transmitter might be a simple beacon device, and not transmit any data. On the other hand, it might be encoded to let you know which of several animals is being received (this is especially important if the same frequency is used for several animals).

Figure 1 shows a national radio telemetry system. At the remote site, some sort of sensor is used to convert the physical parameter being collected into an analog current or voltage. In some cases, the analog signal will be applied to an analog-to-digital converter (A/D), before being applied to the modulator and transmitter. Some sensors produce digital output, but those include an internal A/D converter. In other cases, the "A/D" converter is replaced by a voltage-to-frequency converter (V/F) that will produce an audio frequency proportional to the applied voltage. Whichever is used, the composite signal will be applied to a transmitter, which produces a radio frequency (RF) signal, and sends it to the antenna. The antenna radiates it to a remote receiver site.

The receiver is tuned to the transmitter frequency. It amplifies and demodulates the signal, to recover the original data signal. This signal might either be displayed on a strip chart or other form of paper recorder, or input to a computer (increasingly the case today).

There are a number of low-cost alternatives to the radio transmitter end of the circuit. One method is to use those little handheld kid's walkie-talkies. They typically operate on 49 MHz and are low enough in cost to not break the bank if there is a loss. The audio signal derived from the analog data signal is connected internally to the microphone input line (Note: this might also be the loudspeaker in most models). The push-to-talk switch is then wired into the "transmit" position permanently.

I received a letter once from an amateur rocketry enthusiast who used the printed circuit board recovered from a $10.00 49-MHz walkie-talkie as the telemetry transmitter aboard his rockets. He had a barometric pressure sensor to give him an idea of the altitude. The sensor was used to modulate a V/F converter that, in turn, was applied to the transmitter's audio input.

Another rocketry application was seen in a science fair that I judged. The kid used a similar 49-MHz walkie-talkie to monitor the spin rate of his "bird." He used a phototransistor and operational amplifier to modulate a V/F converter. By monitoring the frequency translations as the rocket rotated on its axis (facing the sun once on each rotation), he was able to record the spinning of the rocket.

One problem might turn up, however. It seems that the audio frequency response of the walkie-talkie is probably limited to the communications equipment standard of 300 to 3,000 Hz (the speech spectrum). If the required audio range exceeds this range, then you might lose data.

A number of frequencies are set aside for this type of application. In the 49-MHz band, there is a 100-KHz range that permits up to 100 milliwatts of RF power, relatively large antennas, and speech modulation. Other frequencies in North America include:

303.825 MHz
418 MHz
433.920 MHz
916.5 MHz

In other parts of the world:

FREQUENCY	BANDWIDTH	POWER	COMMENTS
173 MHz	150 KHz	10 mW	UK
418 MHz	200 KHz	0.25 mW	UK
433 MHz	1,700 KHz	10 mW	Pan-Europe
458 MHz	500 KHz	500 mW	UK
868 MHz	2,000 KHz	25/500 mW	Pan-Europe
1.3 GHz	20 MHz	100 mW	UK (video only)
2.4 GHz	30 MHz	100 mW	World wide (spread spectrum)

The amount of power required for any given application depends on a lot of factors, but there are some "rules of thumb" for reasonably flat terrain (i.e., not big hills in the way).

1. 50 meters: 1 mW and a simple antenna.
2. 500 meters: 10 mW with a good antenna in a good location.
3. 5,000-meters: 100 mW with a good antenna raised at least 10 meters above mean ground level.

You will find that a 1,000 bit/second data rate is easily obtained with audio grade transmitters while, for a 10 kilobits/second, a narrow band 25-KHz channel is needed. Go to 20 kilobits/second and you will need a wideband radio system. At 100 kilobits/second, a professional system is probably needed.

A number of firms (some of which advertise in *Nuts & Volts*) offer small printed circuit board transmitters, receivers, or transmitter/receiver combinations that can be used for telemetry applications. These products are usually designed to be used as if they were integrated circuits (i.e., after the manner of BASIC Stamps and PicoStix processors).

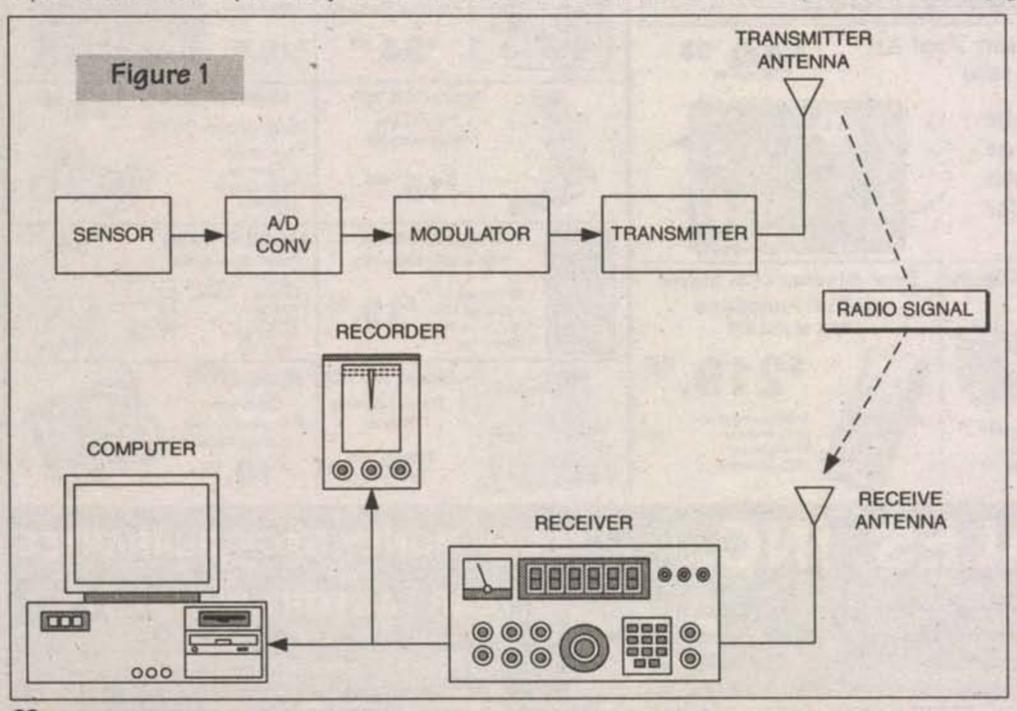


Figure 1

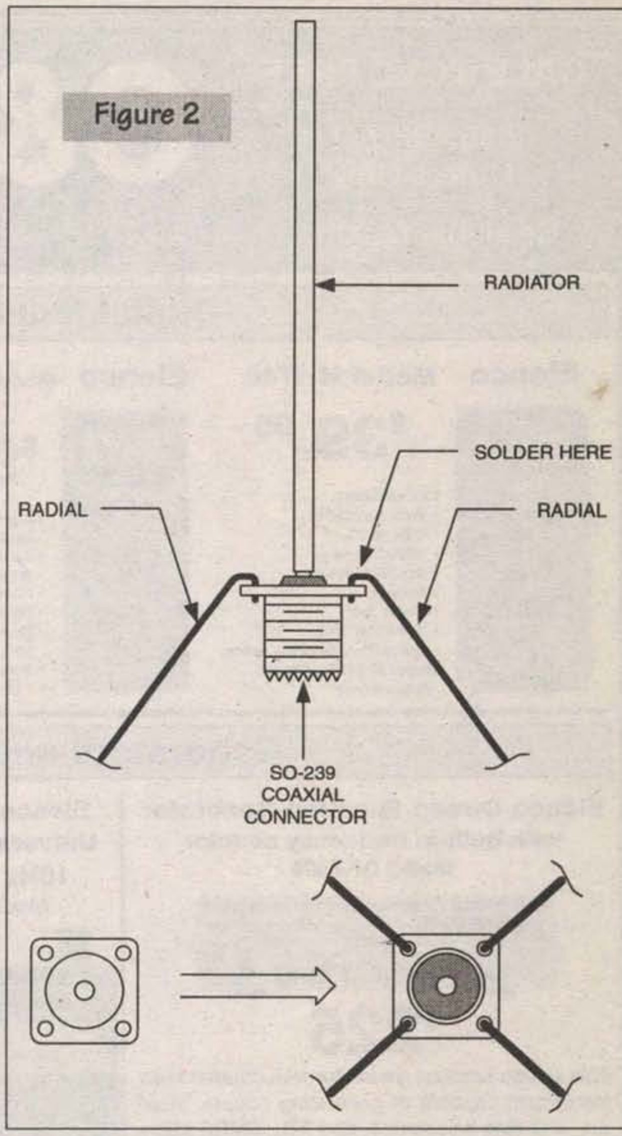


Figure 2

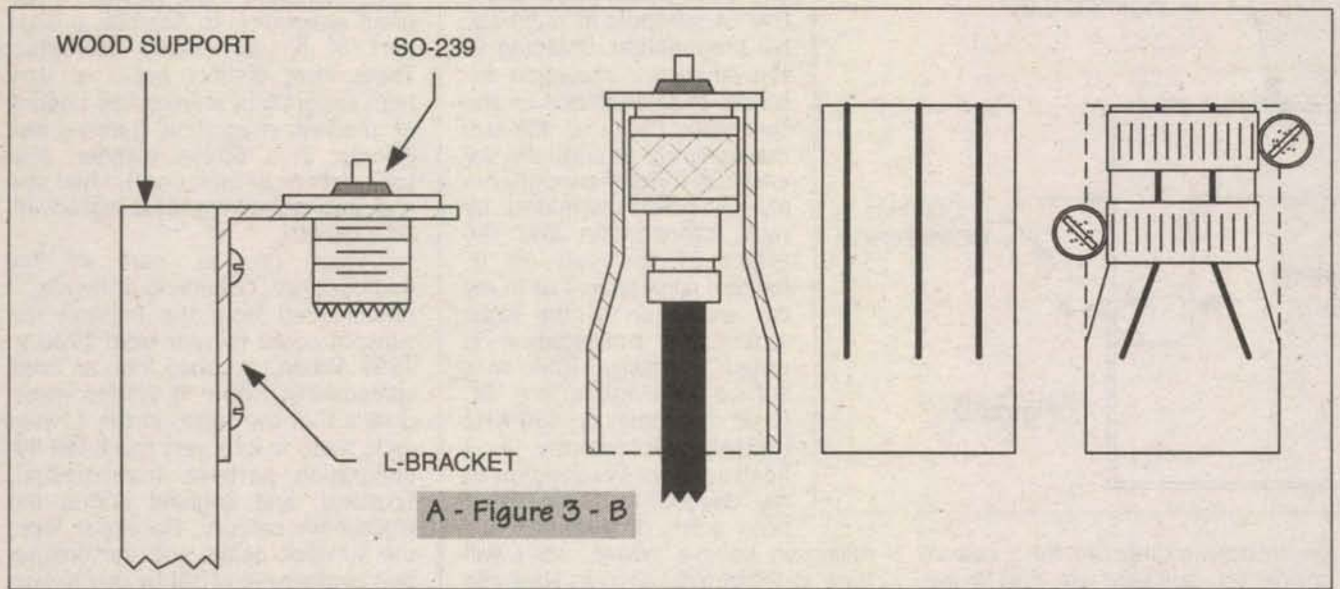
Antennas

A number of different types of antennas can be used for the telemetry transmitter and receiver. In this section, we will look at several forms that are easily implemented.

VHF/UHF Ground Plane Antenna

Figure 2 shows a vertically-polarized ground plane antenna for VHF and UHF bands. This type of antenna produces a vertically-polarized omnidirectional radiation and reception pattern. It can therefore be used for a transmitting site where the receiver might be in any direction, or the opposite, i.e., a receiving site where one or more transmitters might be at various azimuthal angles.

The antenna of Figure 2 uses a



A - Figure 3 - B

single vertical radiator element that is a quarter wavelength long, and four dropping radials, which are also a quarter wavelength long. The

$$L = \frac{7041}{F_{MHZ}} \; cm$$

lengths of these elements can be found from:
where:

L is the length of a radiator or radial in centimeters (cm)

F_{MHz} is the design frequency in Megahertz (MHz)

The antenna is constructed on a chassis mountable SO-239 coaxial connector. The radiator element is made of copper or brass rod that is sized to slip over the solder connector for the center conductor on the SO-239. You will find lengths of brass tubing of suitable dimensions at hobby shops (the sort that cater to model builders) and craft shops.

The four radials are made from either very stiff solid copper wire (#8 to #12) or brass rods (which can be obtained in the same display with the tubing mentioned above). Some people use brazing rod for the radials, but they are a little hard to work in my opinion. The ends of the radials are bent into a hook and inserted into the screw holes on the SO-239. Once seated and positioned correctly (see top view inset to Figure 2), they are soldered in place. Use 60/40 or 50/50 lead/tin radio-electronic solder, *NOT* plumber's solder.

Mounting details for the ground plane antenna are shown in Figure 3. Two methods are shown. In Figure 3A, the SO-239 is mounted on an L-bracket that is screwed to a wooden lumber support. If the L-bracket is made of steel, copper, or brass, then the SO-239 can be soldered to the bracket at the same time the radials are soldered to the SO-239 (makes it easier).

The other method uses a piece of PVC pipe to hold the antenna (the radials are not shown for simplicity). A sectioned view in Figure 3B shows the PL-259 on the end of the coaxial cable screwed onto the SO-239, with the PVC pipe around it. Also shown in Figure 3B is the preparation and final assembly. To prepare the PVC, use a small saw to slit the end as shown. Insert the antenna and feedline, and then place a pair of hose clamps over the end. Cinch the hose clamps down to make the assembly stable.

Vertical Collinear J-Pole Antenna

Figure 4 shows a collinear J-pole antenna. Like the ground plane in Figure 3, it has an omnidirectional azimuthal pattern, but provides some amount of signal gain over the ground plane. The antenna consists of two 5/8-wavelength sections ("A") separated by a phasing harness ("B"). At the bottom of the antenna is a matching section that matches the

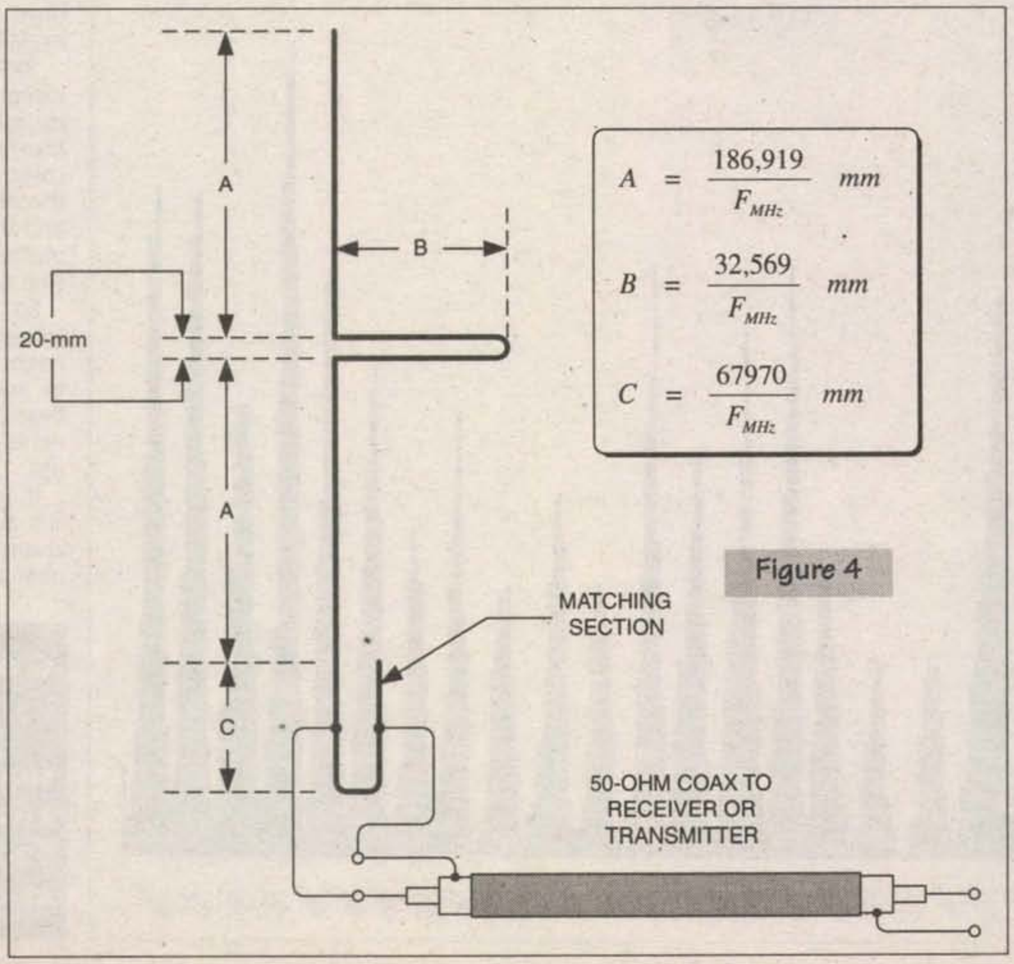
$$A = \frac{186{,}919}{F_{MHZ}} \text{ millimeters}$$

$$B = \frac{32{,}569}{F_{MHZ}} \text{ millimeters}$$

$$C = \frac{67{,}970}{F_{MHZ}} \text{ millimeters}$$

impedance of the coaxial cable to that of the antenna base. The dimensions of the antenna in Figure 4 are:

The antenna can be constructed of #10 solid copper wire on the cheap, or small diameter, brass tubing of the sort mentioned above for the ground plane. Attach the coaxial cable about 2.5 cm from the bottom of the matching section and measure the VSWR. If it is satisfactory, then



$$A = \frac{186{,}919}{F_{MHz}} \; mm$$

$$B = \frac{32{,}569}{F_{MHz}} \; mm$$

$$C = \frac{67970}{F_{MHz}} \; mm$$

Figure 4

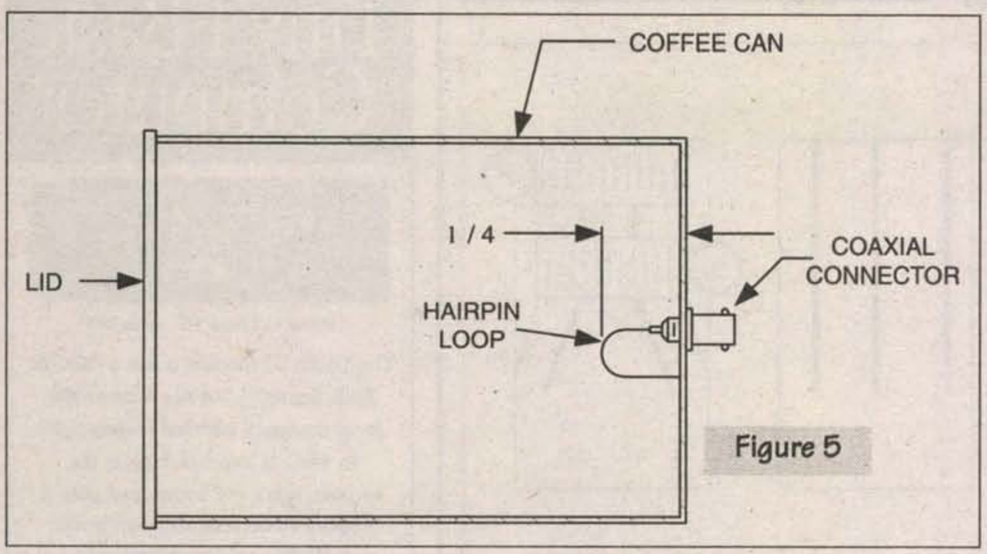


Figure 5

solder it in place. Otherwise, move the connection point while monitoring the VSWR until as close to 1:1 as possible is obtained.

Coffee Can Microwave Antenna

When I was in college, a number of engineering students were making 2.145-GHz microwave antennas using two-pound coffee cans. Their purpose was to pick up the multipoint distribution service (MDS) microwave signals that carried movie channels to apartment house and hotel customers ... until the Dean stopped it (it was illegal). Another group that uses the antenna is the amateur astronomers; some of whom use it as a feed horn for a parabolic dish (many TVRO dishes are on the used market cheap because of direct digital satellite TV). Some hams also use this form of antenna. Figure 5 shows the basic construction.

A hole is drilled in the center of the bottom of the can for a coaxial connector suitable to microwave applications. Most of the engineering students used an ordinary BNC connector, although other forms might be more suitable. A small hairpin pick-up loop is connected to the center conductor of the connector, and soldered to the bottom of the can beside the connector. The loop should be about a quarter wavelength long. Some people used a small microwave half wavelength dipole element at that point.

This antenna assumes that you want to route a signal to a receiver. Mount a low-noise preamplifier on the bottom of the can, before the signal is sent down the coaxial cable to the receiver. The lid can be used to weatherproof the antenna, although a small amount of signal loss will occur.

Sunspots ... and Genealogy?

If you are a radio hobbyist, then you undoubtedly know of the role of sunspots in radio signal propagation. Listening to the variation in reception distances and conditions on the shortwave bands as the sun makes its trip through the sky each day it proof enough. I've always been fascinated by radio propagation and the effect of the sun on it. Indeed, sometimes I sit in my car and listen to the radio when odd propagation is noted. Normally, I listen to a station in Washington, DC (near my home) on 630 KHz (WMAL). Occasionally, as I head south of Washington to my "day job" at 0630-0700, I note a lot of AM BCB DX rolling in behind WMAL, so I will tune to WSM (650 KHz) in Nashville (besides, I like the early morning bluegrass show).

Because I listen as the sun comes over the horizon, I can hear the different effects as the propagation gets unstable and WSM fades while WMAL gets stronger. One time, a colleague saw me just sitting in my car, and asked if anything was wrong (he knows I've had some heart problems). I told him " ... no, but thanks for asking ... I'm just listening to the sun come up." I think he thinks I'm nuts ... "listening to the sun come up?" Radio guys can do that, you know.

Another of my many passions is genealogy. In that capacity, I am Co-Director for Genealogy of the Kerr Family Association ("Kerr" and "Carr" are the same surname), and Genealogy Editor for a magazine called *The Highlander* (of interest to people of Scottish descent).

During my genealogy studies, I became interested in emigration patterns. Although there was some religious emigration to America, a large part of it was strictly economic. There were distinct peaks of very high emigration, followed by periods of modest emigration (braving the Atlantic in a 60-ton wooden ship took guts or desperation!). I had several graphs showing these highly variable periods.

Later on, as part of my RadioScience Observing interests, I downloaded from the Internet the sunspot count by year from 1700 to 1997. When I graphed it on an Excel spreadsheet (Figure 6), I noted immediately that the spikes in the 11-year cycle seem to look very much like the emigration patterns from Ireland, Scotland, and England during the eighteenth century. On closer look, the sunspot peaks and the emigration peaks were offset by one to two years, but otherwise were identical. In my genealogy column in the other magazine, I listed this as a "mystery," but received answers almost immediately. And I should've been able to figure it out for myself.

Three scientists – one a climatologist, one an operations research analyst, and the other a meteorologist – also genealogy fans I presume, read the column and supplied the answer. Sunspots affect the weather rather profoundly, and the weather affects crops. When the crops failed in the eighteenth century, famine followed the next year ... which is why the patterns were offset by one to two years.

The ops research person pointed out that the relationship between sunspots and crops was used in the late nineteenth century to demonstrate to statistics students why correlation does not mean causality. After all, how in the world could there be a relationship between spots on the sun and crops on earth? But later, the causal mechanism was discovered and explained.

Today, we could use exactly the same information to demonstrate causality according to the Tukey-Mosteller criteria that there be coincidence of the phenomenon, thereby sensitivity (change one and the other changes too), and a mechanism by which the relationship can be explained physically.

So, if you are a radio fan, remember that your ancestors might have moved from one place to another in whatever continent they originated, or between continents, because Old Sol was acting up!

If you know of other oddities, like the sunspots and emigration connection, then I would like to hear about them. **NV**

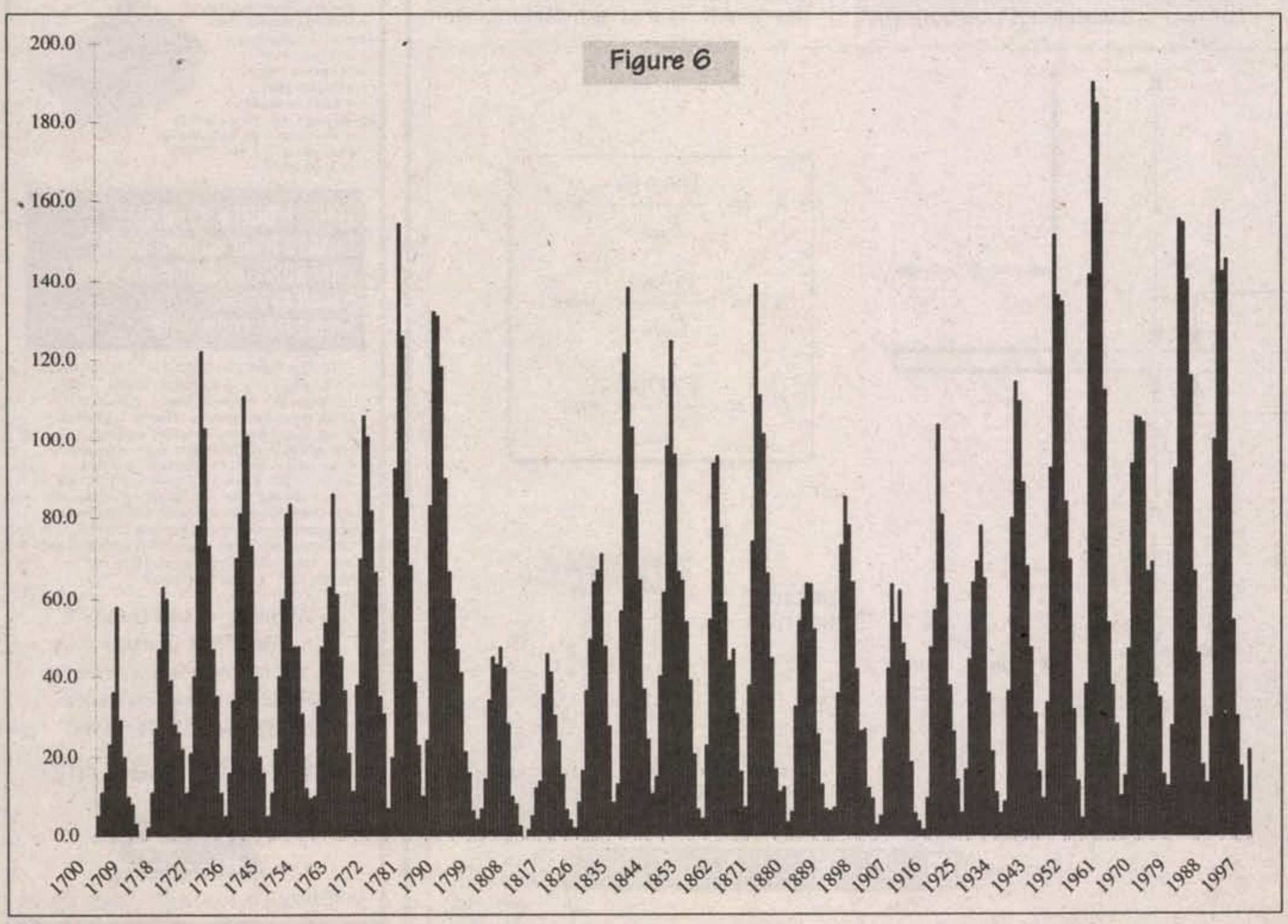


Figure 6

Connections ...

I can be reached by snail mail at P.O. Box 1099, Falls Church, VA 22041, or via E-Mail at CARRJJ@AOL.COM.

Newsbytes

TRENTON COMPUTER FESTIVAL UPGRADED TO LARGER VENUE

Talk about your computer upgrades ... on May 1 & 2, 1999, the Trenton Computer Festival will be relocated from Mercer County Community College to the spacious NJ Convention and Exposition Center at Raritan Center in Edison, NJ.

In its 24th year, the "world's longest running computer show" has opted to relocate to make the show more user-friendly. While very successful in its previous location, TCF had a space problem. Hundreds of seminars took place in various buildings across the campus and exhibitors were dispersed into small areas. Now, show coordinators are thrilled to put everything under one roof with 140,000+ sq. ft. of exhibit space, creating a larger area for the tens of thousands of visitors. This means more vendors, more space to shop, and easier access and continuity to the many interesting seminars and workshops taking place throughout the weekend.

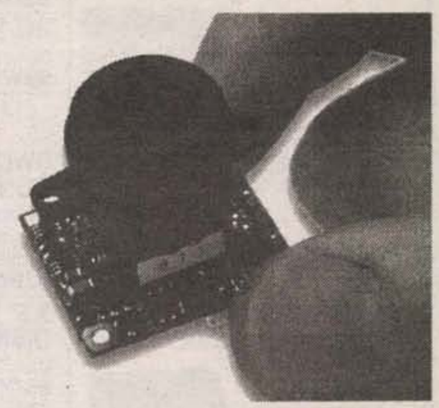
TCF will feature hundreds of exhibits and seminars, guest speakers, special activities, an Internet cafe, and a 1,000 space outdoor market, complete enough for the novice to the most experienced end-user. Computer professionals will be able to talk with many potential employers at the planned on-site hi-tech job fair.

Owned and sponsored by area non-profit computer clubs (501-C-3 status), proceeds will be applied to club operations and scholarship funds at The College of New Jersey. These clubs are the Amateur Computer Group of New Jersey, Central Jersey Computer Club, The College of New Jersey, IEEE-CS/ASM, Princeton Chapter, the Computer Education Society of Philadelphia, and the New York Amateur Computer Club. In addition, the show will now be managed by KGP Productions, the oldest and largest PC Show promoter in the Northeast.

Trenton Computer Festival is the computer place to show, learn, and surf the web, all under one roof. Now that is an upgrade.

For additional information, check the Trenton Computer Festival website at **www.tcf99.com**. Ms. Marin Light, **KGP Productions 1-800-631-0062**. E-Mail: **marinlight@earthlink.ne**t.

SUPERCIRCUITS CAMERA USED ABOARD NASA SPACE FLIGHT

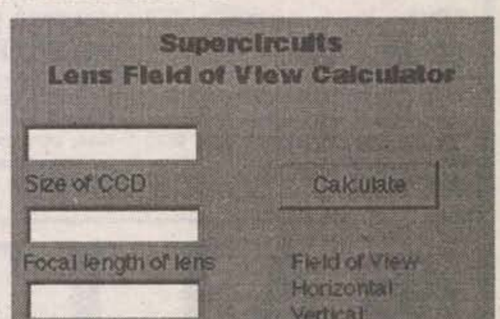


NASA recently launched an inexpensive Supercircuits video camera into space. This is the same technology that is available to the general public for under $150.00.

The Supercircuits PC-67XS camera sent back flawless video, and even unexpectedly survived the intense heat of re-entry.

Complete footage of the launch, including stunning orbital footage from the Supercircuits PC-67XS, can be seen on . the Internet at: ftp.wff.nasa.gov/pub/36150/movie. Footage can also be seen at the Supercircuits website, which is www.supercircuits.com.

SUPERCIRCUITS WEBSITE ADDS ONLINE LENS FIELD OF VIEW CALCULATOR



Supercircuits has added a handy java applet to their website which is sure to please anyone needing to select a lens for any video application.

The user simply enters the camera's CCD size, lens focal length, and distance to subject. Exact field of view in horizontal and vertical feet is then displayed. The program handles 1/5", 1/4", 1/3", and 1/2" CCD format sizes.

The Supercircuits online lens calculator can be found on the Internet at www.supercircuits.com.

SUPERCIRCUITS
ONE SUPERCIRCUITS PLAZA, LEANDER, TX 78641

Events CALENDAR

MARCH 1999

The Events Calendar is a free service for publicizing electronic events such as amateur radio hamfests, flea markets, etc. If your organization is sponsoring an event and would like a free listing, contact us at least 60 days in advance. Include your flyer, estimated attendance, name of the person to contact, and phone number.

Complimentary issues are available upon request for distribution to your attendees. A street address for UPS is required.

While we strive for accuracy in our calendar, we can not be responsible for errors or cancellations. The information contained in this column is for the use of the readers of *Nuts & Volts* and may not be republished in any form without the written permission of T & L Publications, Inc.

All listing information should be sent to:
Nuts & Volts Magazine
Events Calendar
430 Princeland Court
Corona, CA 91719
Phone 909-371-8497
Fax 909-371-3052
E-mail events@nutsvolts.com

MARCH 5

MO - ST. LOUIS - Hamfest. Amateur Radio Auction, Bill Schmidt WA0JCO, 314-544-1515

MARCH 5-6

MS - PASCAGOULA - Hamfest. Jackson County Fairgrounds, Civic Center. Fri: 5pm-9pm, Sat: 8am-3pm. VE Exams. Talk-in: W5WA 145.110-. Jackson County ARC, Charles F. Kimmerly, 228-826-5811

MARCH 5-6-7

NE - NORFOLK - State Convention. Fred Wiebelhaus N0VLX, 402-379-1929. E-Mail: dfwiebel@sufia.net Web: http://members.aol.com/davidn0xbn/evarc.html

MARCH 6

CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052

NJ - PARSIPPANY - Hamfest. PAL Building, Smith Field, Rt. 46 & Baldwin Rd. VE Exams. Splitrock ARA, Mark Turner KB2VKO, 973-347-3195 or 1-888-511-7272. E-Mail: mlturner@bellatlantic.net Web: http://ham.hsix.com/sara

TN - KNOXVILLE - Hamfest. Kerbela Temple, 315 Mimosa Ave. 8am-4pm. Talk-in: 144.83/145.43 or 146.52 simplex. Kerbela ARS, Paul Baird K3PB, 423-986-9562

MARCH 6-7

FL - NEW PORT RICHEY - Hamfest. Fred K. Marchman Technical Educational Center. Sat: 8am-5pm, Sun: 8am-3pm. Talk-in: 146.670 or 145.330. Gulf Coast ARC, Rick Brown KF4GXS, 813-842-2127. E-Mail: richar@gte.net

MARCH 7

FL - ZEPHYRHILLS - Hamfest. Zephyrhills ARC, Ernie Vanselow KD4VRV, 813-783-8389. E-Mail: kd4vrv@gte.net

MA - WESTFIELD - Hamfest. Westfield South Middle School. MTARA, Jim Allen N1RUT, 413-568-1175 days, 413-536-5182 eves. E-Mail: Jim.Allen@the-spa.com Web: http://www.mtara.org

NY - LINDENHURST - Hamfest. Great South Bay ARC & Suffolk County RC, 516-422-9594. E-Mail: ka2d@li.net Web: http://www.gsbarc.org

WI - WAUKESHA - Swapfest. Waukesha County Expo Center. 8am-2pm. VE Exams. Talk-in: 146.82 PL 127.3. SEWFARS, John Breecher N9NWN, 414-835-7035

MARCH 13

AZ - SCOTTSDALE - Hamfest. Scottsdale ARC, Roger Cahoon KB7ZWI, 602-948-3548

CA - FONTANA - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves

CA - LINDA - Hamfest. Yuba Sutter ARC, Clara KC6JPP, 530-742-2674. Ron W6KJ, 530-674-8533

FL - EAST ENGLEWOOD - Hamfest. Tringali Community Center, SR 776. Talk-in: 146.700. Englewood ARS, J.R. House K9HUY, 941-475-3005. George KA4JKY, 941-697-3445. E-Mail: gshreve@ewol.com Web: http://www.flnet.com/~crosby/ears/index.html

FL - SEBRING - Hamfest. Highlands County ARC, Phyllis Dibble KD4CQG, 941-465-8176. E-Mail: dibble@strato.net Web: http://www.strato.net/~hamradio

KY - CAVE CITY - Hamfest. Mammoth Cave ARC, Larry Brumett KN4IV, 502-651-2363. E-Mail: lbrumett@glasgow-ky.com Web: http://www.scrtc.blue.net/mcarc

MO - KANSAS CITY - Hamfest. Ararat Temple, 5100 Ararat Dr. Ararat AR Shrine Club, Steve Dowdy WJ0I, 816-941-3392. E-Mail: sdowdy@qni.com

ND - WEST FARGO - Hamfest. Fairgrounds. 8am-3pm. VE Exams. Talk-in: 146.76-. Red River Radio Amateurs, Mark Kerkvliet KG0FR, 701-282-4716. E-Mail: mbkerk@worldnet.att.net Web: http://www.rrra.org

NJ - WEST ORANGE - Hamfest. High School, 600 Pleasant Valley Way. 8:30am-1pm. Talk-in: 146.415 +1.0 85.4T, 224.480 -1.6 no tone, 447.875 -5.0 156.7T, 146.520 simplex. IRAC, Jim Howe N2TDI, 973-402-6066. E-Mail: n2tdi@juno.com

WA - PUYALLUP - Hamfest. Mike & Key ARC, Michael Dinkelman N7WA, 253-631-3756 or 425-867-4797. E-Mail: mwdink@eskimo.com

MARCH 13-14

NC - CHARLOTTE - Hamfest & Computerfair. Charlotte Merchandise Mart, 2500 E. Independence Blvd. Mecklenburg ARS, Tim Slay WO4G, 704-382-3234 (W) or 704-948-6283 (H). E-Mail: wo4g@w4bfb.org Web: http://www.w4bfb.org/hamfest.html

LA - RAYNE - Hamfest. Acadiana ARA, Nolen Griffith K5ARH, 318-989-9039. E-Mail: k5dpg@aisp.net Web: http://www.acadian.net/w5ddl/

MARCH 14

IL - STERLING - Hamfest. High School Fieldhouse, 1608 4th Ave. Talk-in: 146.25/146.85 W9MEP. Sterling-Rock Falls ARS, Lloyd Sherman KB9APW, 815-336-2434. E-Mail: lsherman@essexl.com

IN - INDIANAPOLIS - Hamfest. State Fairgrounds. Morgan County Repeater Assn., Dennis Bauernfiend WB9ZNZ, 317-996-3782. E-Mail: dennis.bauernfiend@dfas.mil Web: http://www.eb1.com/mcra

OH - CONNEAUT - Hamfest. Human Resources Center, 327 Mill St. Conneaut ARC, Jack Marttila KA8TUU, 440-593-3353

MARCH 19-20

FL - FT. WALTON BEACH - Hamfest. Playground ARC, Clyde Gowdy KE4FLC, 850-244-0624. E-Mail: parcfest@aol.com

ME - LEWISTON - ME State Convention. Androscoggin ARC, Ivan Lazure N1OXA, 207-784-0350. E-Mail: ilazure@gwi.net

OK - TULSA - OK State Convention. Maxwell Conv. Center, 700 S. Houston Ave. Talk-in: 145.11 & 443.85. Green Country Hamfest Assn., Merlin Griffin WB5OSM, 918-622-2277. E-Mail: info@GreenCountryHamfest.org Web: http://www.GreenCountryHamfest.org

MARCH 20

AR - JONESBORO - Hamfest. Jonesboro ARC, Mike Conley KC5ISI, 870-931-9957. Evelyn Castleberry N5DSY, 870-932-1660. E-Mail: jsnodgra@insolwwb.net

CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052

FL - STUART - Hamfest. Martin County ARA, David Millard KE4AMW, 561-288-7100

GA - MARIETTA - Hamfest. Kennehoochie ARC, Ben Dasher KE4YZX, 404-869-6959. E-Mail: bendasher@mindspring.com Web: http://qsl.asti.com/hootch/KARC.html

MI - MARSHALL - Hamfest. Southern Michigan ARS & Marshall HS Photo Electronics Club, Wes Chaney N8BDM, 616-979-3433. E-Mail: n8bdm@voyager.net

OH - COALTON - Hamfest. Jackson County ARC, Edgar Dempsey KD8XL E-Mail: pops82@juno.com

MARCH 20-21

TX - MIDLAND - Hamfest. Midland ARC, Beverley Harwood KC5BNT, 915-686-1841. E-Mail: shamrock@apex2000.net Web: http://www.lxnet/edge/midswap.htm

MARCH 21

CT - SOUTHINGTON - Hamfest. Southington ARA, Chet Bacon KA1ILH, 860-628-9346. E-Mail: hcbacon@connix.com Web: http://www.connix.com/~hcbacon/sara.html

IL - TAYLORVILLE - Hamfest. Christian County ARC, Walt Harwell N9KNF, 217-287-2010. E-Mail: harwell1@juno.com

NC - KINSTON - Down East Hamfest. Lenoir County Fairgrounds, Hwy. 11 S. 8am-3pm. Doug Burt W4OFO, 252-524-5724

NJ - TRENTON - Hamfest. Tall Cedars of Lebanon picnic grove, Sawmill Rd. Talk-in: 146.67-. Delaware Valley Radio Assn., Darryl Foyuth N2JVP, 609-882-2240 E-Mail: n2jvp@amsat.org Web: www.slac.com/w2zq

NY - YONKERS - Hamfest. Yonkers Raceway, Central Ave. and Yonkers Ave. 8am-2pm. VE Exams. Talk-in: 147.060 PL 114.8. Thomas Raffaelli WB2NHC, 914-741-6606. Web: www.weca.org

OH - MAUMEE - Hamfest. Lucas County Recreation Center, 2901 Key St. 8am-2pm. Talk-in: 147.27+ or 442.85+. Toledo Mobile Radio Assn., Paul Hanslik N8XDB, 419-243-3836. Web: http://www.tmrahamradio.org

WI - JEFFERSON - Hamfest. Tri-County ARC, Glenn Eisenbrandt WA9VYL, 920-563-6502. E-Mail: tricountyarc@globaldialog.com

WV - CHARLESTON - Hamfest. Charleston Area Hamfest & Computer Show, Jimmie Hewlett WD8MKS, 304-768-1143

MARCH 27

CT - POMFRET - Hamfest. Eastern CT ARA, Paul Rollinson KB1CNW, 860-928-2456. E-Mail: paulrollinson@worldnet.att.net

COMPUTER SHOWS

AGI Shows, 317-299-8827. E-Mail: info@agishows.com http://www.agishows.com

Blue Star Productions 612-788-1901 http://www.supercomputersale.com

Computers And You, 734-283-1754. www.a1-supercomputersales.com

Computer Central Shows 847-412-1900 & 1-888-296-6066. E-Mail: compcent@megsinet.net www.computercentralshows.com

Five Star Productions 810-890-0988 E-Mail: jeff@fivestar www.fivestarshows.com

Georgia Mountain Productions 706-838-4827. E-Mail: gamtnpro@blrg.tds.net georgiamountain.com

Gibraltar Trade Center, Inc. 734-287-2000. Taylor, MI.

Gibraltar Trade Center, Inc. 810-465-6440. Mt. Clemens, MI.

MarketPro, Inc., 201-825-2229 http://www.marketpro.com

MarketPro, Inc., 301-984-0880. E-Mail: md@marketpro.com http://marketpro.com

Narisaam Computer Show 770-663-0983. E-Mail: narisaam@aol.com Web: http://www.shownsale.com

Northern Computer Shows 978-744-8440 E-Mail: inquiries@ncshows.com Web: ncshows.com

Peter Trapp Computer Shows, 603-272-5008. Web: www.petertrapp.com

Events CALENDAR

CT - WATERFORD - Auction. Waterford Senior Center, Rt. 85. Talk-in: 146.730-. RAS of Norwich, Tony Griggs AA1JN, 860-859-0162. Mark Venable N1RSK, 860-572-9380, E-Mail: mvenable@99main.com Web: www.ims.uconn.edu/~rason
IN - COLUMBUS - Hamfest. Bartholomew County 4H Fairgrounds, Community Bldg., SR 11. 8am-2pm. Talk-in: 146.790/146.190. Columbus ARC, Marion Winterberg WD9HTN, 812-342-4670. E-Mail: winterbe@hsonline.net
IN - MICHIGAN CITY - Hamfest. High School, 8466 W. Pahs Rd. 8am-1pm. Michigan City ARC, Inc., Ron Stahoviak N9TPC, 219-325-9089
NY - NEWARK - Hamfest. Drumlins ARC, Jeff Jensen N2MKT, E-Mail: n2mkt0@aol.com
TX - WEATHERFORD - Hamfest. ARC of Parker County, Elizabeth Hunkele N5ONE, 817-594-1700. E-Mail: eliz@mesh.net

MARCH 27-28

MD - TIMONIUM - Maryland State Convention. Timonium Fairgrounds. Sat: 8am-5pm, Sun: 8am-4pm. Sharon Dobson N3QQC, 410-HAM-FEST (Box 3772), 1-800-HAM-FEST (Box 3772). E-Mail: n3qqc@amsat.org Web: http://www.gbhc.org

MARCH 28

CA - SANTA ANA - Swapmeet. ACP parking lot. Mary Russo 714-558-8813
FL - LEESBURG - Hamfest. Lake ARA, Paul Branch K3NON, 352-343-8729. John Wentz W8HFK, E-Mail: w8hfk@aol.com
IL - GRAYSLAKE - Hamfest. North Shore RC, Libertyville & Mundelein ARS, Anne Diamond N9QFP, 847-272-8347
NH - HENNIKER - Hamfest. Contoocook Valley RC, Jock Irvine N1JI, 603-428-3476 ext. 256
OH - MADISON - Hamfest. Lake County ARA, Roxanne, 440-256-0320

APRIL 1999

APRIL 2-3

OK - MOORELAND - Hamfest. Tri-State AR Group, Duane Henderson KC5NID, 580-994-2223. E-Mail: kc5nid@pldi.net

APRIL 2-3-4

GA - AUGUSTA - Hamfest. Radisson Hotel & Conference Center, 2 10th St. Garden City Channel Masters CB Club, Inc., Moses 706-793-7828

APRIL 3

CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052

APRIL 9-10

GA - ATLANTA - Southeastern VHF Conference. Southeastern VHF Society, Dick Hanson K5AND, 770-844-7002. E-Mail: k5and@prestique.net Web: http://www.svhfs.org.svhfs

APRIL 9-10-11

CA - FRESNO - Int'l DX Convention. Gordon Girton W6NW. E-Mail: gordon@svpal.org E-Mail: w6nw@amateur-radio.org Web: http://www.amateur-radio.org/ncdxc.org

APRIL 10

CA - FONTANA - Inland Empire ARC Amateur Radio & Electronics Swapmeet. A B Miller High School. Bill 909-822-4138 eves
MN - ROCHESTER - Hamfest. Rochester ARC, John Scott N0HZN, 507-285-6522. E-Mail: n0hzn@aol.com Web: http://members.aol.com/rarchams/
NC - MORGANTON - Hamfest & Computer Fair. Burke County Fairgrounds, Hwy. 181N (Exit 100 Eastbound, Exit 105 Westbound I-40). 8am-5pm. Talk-in: 147.15 (K4VLY repeater). Catawba Valley, Tom Tayler, 704-433-6205. E-Mail: kc4qpr@vistatech.net
NH - TWIN MOUNTAIN - Hamfest. Town Hall. 8am-2pm. VE Exams. Talk-in: 147.345. North Country ARC and LARK, Richard Force WB1ASL, 603-788-4428. E-Mail: bhabooks@together.net
WA - SPOKANE - Hamfest. Spokane Community College, 1810 N. Greene St. 9am-5pm. VE Exams. Talk-in: 146.52 simplex, 147.32 repeater. Lilac City ARC, Warren Kelsey KJ7BB, 509-534-8443

APRIL 11

CT - BRISTOL - Hamfest. Insurance City Repeater Club, Jack McLaughlin WK1S, 860-621-6623. E-Mail: wk1s@aolcom Web: http://www.connix.com/~pcb/icrc-fle.htm
IA - DELOIT - Hamfest. Denison Repeater Association, John Amdor III KD6MXL, 712-388-8042. E-Mail: johnmxl@radiks.net Web: http://www.radiks.net/~johnmxl/deloit.html
MA - FRAMINGHAM - Hamfest. Framingham ARA, Beverly Lees N1LOO, 508-626-2012
NC - RALEIGH - RARSFest. State Fairgrounds, Jim Graham Bldg. 8am-4pm. Raleigh ARS, Wilbur Goss WD4RDT, 919-266-9883. E-Mail: k4hf@juno.com
NY - MONTGOMERY - Hamfest. Valley Central High School, 1175 St. Rt. 17K. 8am-2pm. VE Exams. Talk-in: 146.160 in, 147.760 out 100 Hz PL tone. Orange County ARC, Edward J. Moskowitz N2XJI, 914-534-3492 eves. E-Mail: n2xji@banet.net
WI - MADISON - Hamfest. Madison Area Repeater Assn., Paul Toussaint N9VWH, 608-245-8890. E-Mail: n9vwh@hotmail.com

APRIL 17

AL - ALBERTVILLE - Hamfest. Marshall County ARC, Buddy Smith KC4URL, 256-593-2516. E-Mail: kc4url@airnet.net
AZ - PHOENIX - Hamfest. Arizona ARC, George Cooney KQ7C, 602-274-6212. E-Mail: georgie@aztec.asu.edu
CA - SANTEE - ARC of El Cajon Ham, Computer & Electronic Swapmeet. Santee Drive-in. 619-561-0052 Web: http://www.srv.net/~wa4vrv/hamfest.htm
FL - MIAMI - Hamfest. Flamingo, Univ. of Miami ARC UM Campus, Physics Parking Lot. Talk-in: 146.865 (-). Walt W4DWN, 305-895-0398
ID - IDAHO FALLS - Hamfest. Elks Lodge, 640 E. Elva St. VE Exams. Talk-in: 443.00 MHz + UHF, 147.15 MHz + VHF. Eastern Idaho UHF Society, Jay Greenburg WA4VRV, 208-524-1388. E-Mail: wa4vrv@srv.net
KY - MURRAY - Hamfest. Murray State University ARC, Pat Compton KF4FMZ, 502-762-6433. E-Mail: patrick.compton@murraystate.edu Web: http://mursuky.edu/clubs/msuarc/hamfest.htm
MN - BLAINE - Hamfest. National Sports Center, 35W, Exit #32. 7:30am-3pm. Jerry Dorf N0FWG, or Harriet Johanson 612-537-1722. E-Mail: jerryd@skypoint.com
MO - JOPLIN - Hamfest. Joplin ARC, Ray Brown KB0STN, 417-781-4967. E-Mail: raybrown@ipa.net Web: http://www.joplin-arc.org
OK - LAWTON - Hamfest. Lawton Ft. Sill ARC, Bob Morford KA5YED, 580-355-6120 or 580-353-8074
TX - BELTON - Hamfest. Bell County Expo Center. Talk-in: 146.820-, PL 123.0. Temple ARC, Mike LeFan WA5EQQ, 254-773-3590. E-Mail: hamexpo@tarc.org Web: http://www.tarc.org

APRIL 18

CT - HARTFORD - 1999 Trinity College Fire-Fighting Home Robot Contest. Trinity College campus. Jake Mendelssohn, 190 Mohegan Dr., West Hartford, CT 06117. E-Mail: JMENDEL141@AOL.COM Web: http://www.trincoll.edu/~robot
MA - CAMBRIDGE - Flea Market. Kendall Square area. MIT. Nick Alternbernd KA1MQX, 617-253-3776. Web: http://web.mit.edu/w1mx/www/swapfest.html
MN - SHAKOPEE - Hamfest. Canterbury Park. 12pm-5pm. VE Exams. Talk-in: 147.165+. SMARTS, POB 144, Chaska, MN 55318
PA - MONROEVILLE - Hamfest. Two Rivers ARC, Michael Kowalcheck, Jr. KV3L, 412-751-9657

APRIL 23-24

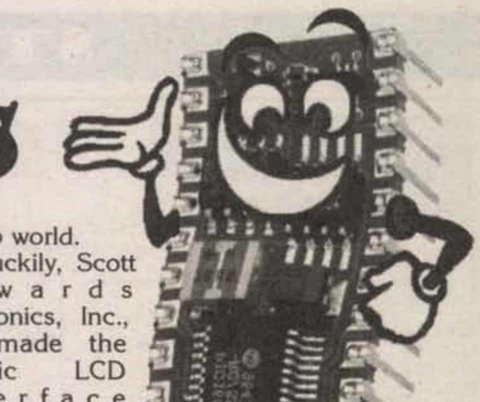
AR - LITTLE ROCK - Hamfest. Expo Center, Exit 126, I-30 SW. Fri: 4pm-9pm, Sat: 8am-4pm. Jim Blackmon K5VZ, 870-246-7833 H, 870-246-6734 W. E-Mail: lrhamfest@usa.net Web: http://www.aristotle.net/~ares/hamfest/
FL - GAINESVILLE - Hamfest. Alachua County Fairgrounds, SR 222. VE Exams. Talk-in: 146.820. Steve King KC6WCH, 352-375-8023 eves. only. E-Mail: gars@afn.org

APRIL 24

AR - BENTONVILLE - Hamfest. Benton County Radio Operators, Betty Weiberg N0XWQ, 417-435-2332
CA - ARMONA - Hamfest. Hanford Fraternal Hall, 10th Ave. @ Florinda. Talk-in: 145.11, 147.33, 224.44 or 441.900. The Kings ARC, Rick WB6VFZ, 209-945-2266. Doug KC6BGQ, 209-582-0949 or 209-584-5414
CA - SONOMA - Hamfest. Sonoma Valley Veteran's Memorial Bldg., 126 1st St. W. 8am-12pm. VE Exams. Talk-in: 145.35, -600 PL 88.5. VOMARC, Darrell Jones WD6BOR, 707-996-4494
IA - DES MOINES - Hamfest. Des Moines RAA, Duane Bower WB0UCY, 515-287-6542
FL - LANTANA - Flea Market. Next to Pizza Hut, 6170 S. Congress Ave. 7am-12pm. Talk-in: 146.67. The Major Armstrong FM Assn., Jeff Beals WA4AW, 561-586-5120. Al West W4SDC,

STAMP APPLICATIONS

by Lon Glazner



Putting the Spotlight on BASIC Stamp Projects, Hints, and Tips

A Powerful Graphic Liquid Crystal Display (LCD)

Overview

There's nothing quite like the beauty of a graphic LCD. Even the simplest electronic design can become a wonder of modern engineering when a "cool" graphic floats across a back-lit graphic LCD.

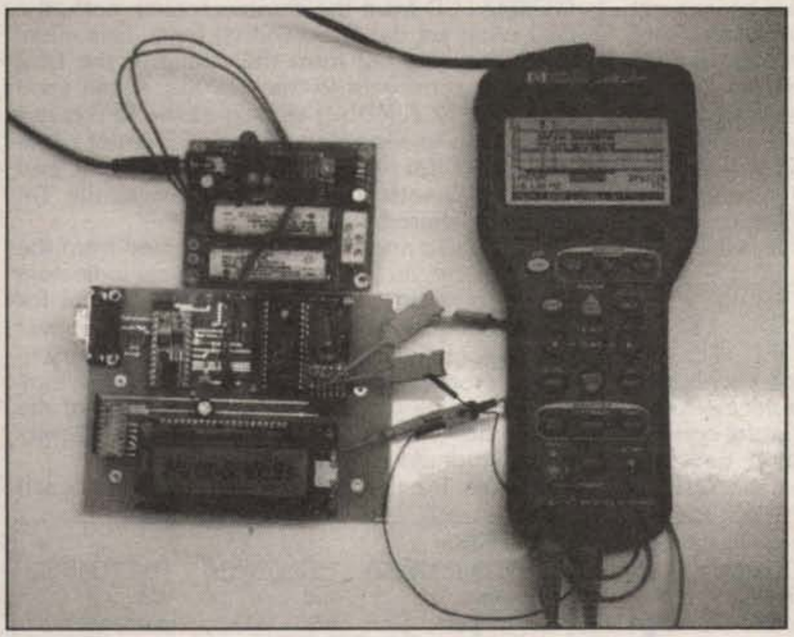
I remember spending hours-upon-hours working for a client to develop a pretty in-depth communication protocol. In the end, I was firm in my belief that the client would heap showers of praise upon my head. After all, I had solved some tricky problems in a short period of time, and with some pretty innovative techniques. When I showed up and delivered the design, my expectations were summarily dashed. It turned out that another consultant had been developing a user-interface based on a graphic LCD for the same design. And you should have seen this thing! Big, bright, and beautiful. I mean, sure, my design was still an integral part of the whole system, but the LCD interacted with the customer, it was beautiful, and it received ample praise.

So what's the point of this experience? I believe that any time you have an opportunity to interface an electronic design with the end user, looks count for something. All the design work in the world, accompanied with flow charts and schematics, may count for less than a good visual display. This is especially true if you are presenting your design to a non-technical group such as a marketing department. Don't get me wrong, I'm not saying that a nifty display replaces good engineering. I'm saying sometimes a nifty display IS good engineering.

So what's the best way to create a graphic LCD solution that functions with your BASIC Stamp design? Generally speaking, graphic LCDs require a lot of memory, and quite a few I/O lines. This is not good news in the Stamp world.

Luckily, Scott Edwards Electronics, Inc., has made the graphic LCD interface astoundingly easy. Most BASIC Stamp users are familiar with the Scott Edwards Electronics, Inc, serial LCD. One of Scott's newer products is the G12032 Mini Serial LCD. This is the LCD that I'm going to use in this design. This graphic LCD is similar in many ways to Scott Edward's other popular serial LCDs. One of the really exciting features of the G12032 LCD is the software provided for use with it. You can use this software to load bit maps from your PC into the G12032's non-volatile memory. We will use this same software to load bit maps from your PC into the RAMPack B, and then transfer the bit maps to the G12032 LCD. Each bit map represents a screen to be displayed on the graphic LCD.

There are quite a few features of the G12032



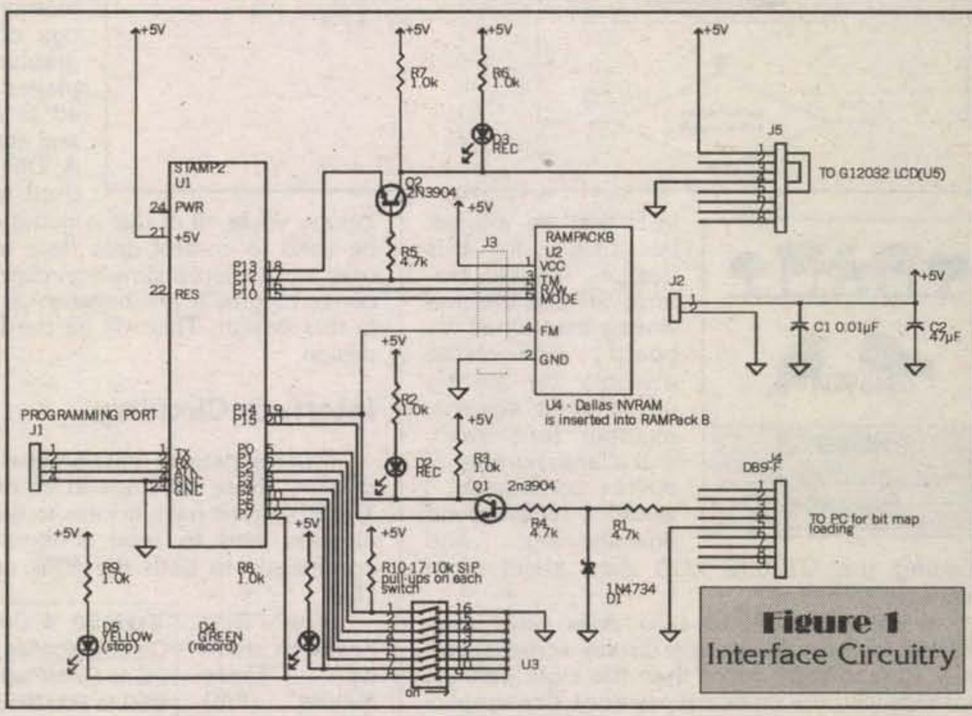


Figure 1
Interface Circuitry

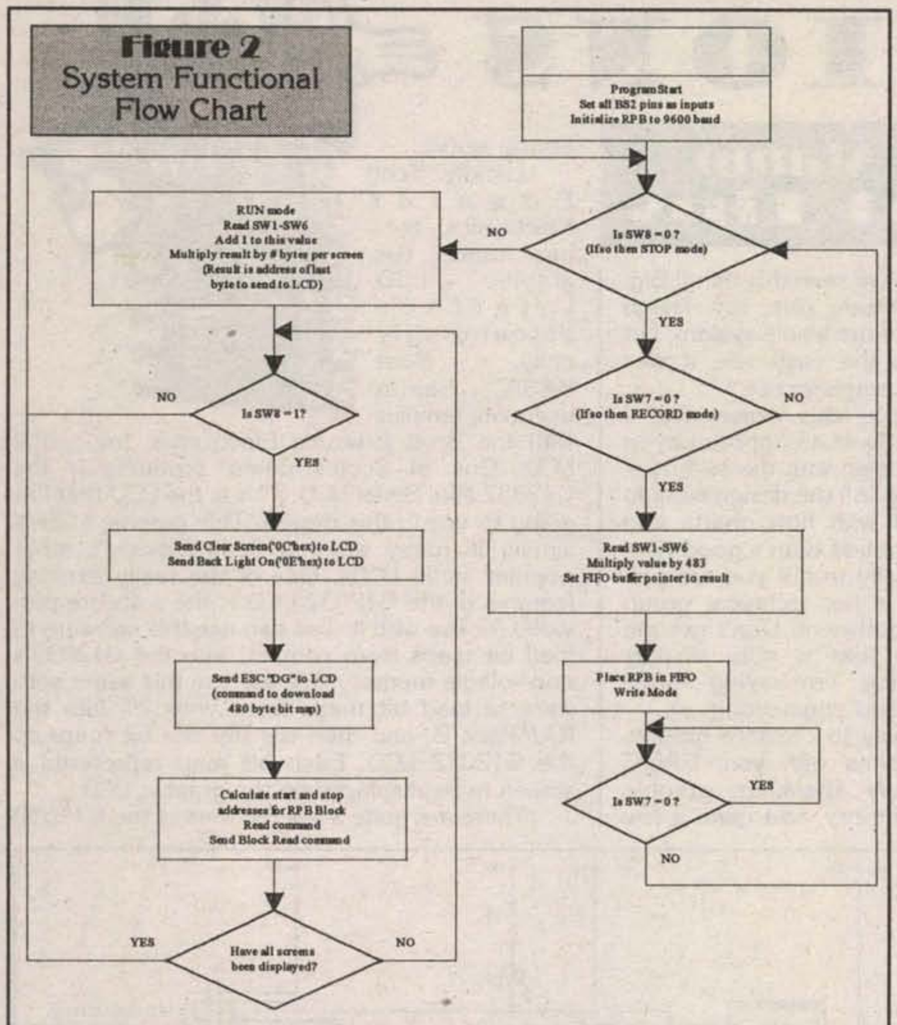


Figure 2
System Functional Flow Chart

Figure 3
Examples of Bitmaps

LCD that we will not be using in this design. These features include the previously mentioned on-board non-volatile memory for storing up to eight screens, multiple font sizes, and a large number of built-in commands. I would recommend downloading and reading the G12032 LCD data sheet from "www.seetron.com."

While the G12032 LCD does have non-volatile memory for storing display screens, you may wish to store more than the eight screens possible with the on-board memory. For simplicity, we will use the RAMPack B (RPB) serial RAM module to provide the extra memory. This device — by Solutions Cubed — can be used to store up to 17 graphic display screens for use with the G12032 LCD. If you were to upgrade the RPB to 32Kx8 RAM, then 67 screens could be stored. These devices work particularly well together because they both make use of serial communication. With a BASIC Stamp 2 (BS2) to act as a traffic director, we will download bit maps from the PC into the RPB, and then use the RPB to send blocks of data to the G12032 LCD for display.

Problem Statement

The goal of this design is to provide a simple graphic LCD display for a BS2. A minimum number of I/O pins will be used to interface to the LCD display and provide memory for the storage of graphics. The graphic files to be displayed will be generated in Microsoft Paint, and stored in the RPB. A DIP switch will be used to simulate user inputs. While all of this is going on, the BS2 will be used to control data flow, and monitor the user input. Some simple circuitry is required to convert signal levels between all of the modules in this design. This will be the first task of this design.

Interface Circuitry

Several data format conversions are required to allow these modules to communicate freely. The BS2 must have access to the serial communication lines to send configuration data and commands to both the RPB and the G12032 LCD.

The RPB needs to share its "From Master" (FM) line with the BS2, and the serial data source. In this case, the serial data source is a PC, and the data is the actual bit map to be stored in the RPB. On top of these requirements, the serial data from the PC is received in RS232 (+12Vdc = logic low, and -12Vdc = logic high) format, and must be converted to a standard logic level (0Vdc = low, 5Vdc = high) format for the RPB. This is easily done via Q1, R4, R1, and D1 seen in Figure 1.

P15 (FMEN in the software listing) of the BS2 must be low (0Vdc) to enable data to travel from the PC to the RPB. Additionally, P14 (FMBS2) should be made an input. With P15 (FMEN) low and P14 (FMBS2) set as an input, any data from the PC will be received in roughly TTL format at the FM pin of the RPB. If the BS2 needs to send serial commands to the RPB, it simply sets P15 (FMEN) high, which effectively removes Q1 from the circuit. With P15 (FMBS2) set high, commands can be sent to the RPB via P14 (FMBS2) in standard TTL format. While the description may seem somewhat complicated, this method of line sharing and format converting is quite simple and works well.

A similar technique of line sharing is used to send data from the RPB to the G12032 LCD. Again, the G12032 LCD requires data in an inverted format. In other words, 0Vdc is regarded as a logic high. Since the RPB handles data in a non-inverted format, Q2 is used to invert the data headed to the G12032 LCD. At some points in the BS2 program, the BS2 will require information from the RPB on the "To Master" (TM) line. At these times, you do not want that information to be passed to G12032 LCD. To remove the G12032 LCD from the communication path, the BS2 must set the P13 (TMEN) high. This effectively removes Q2 from the circuit. If the BS2 needs to send data to the G12032, it can send data via P12 (TMBS2) as long as the RPB is not attempting to send data. If the RPB is not sending data its TM pin is configured as an input, and pulled high with a resistor. This allows the TM line to be shared.

LEDs D2 and D3 could be omitted from the interface circuit. I've found that visual indicators of program flow can be extremely helpful for troubleshooting electronic designs. Whenever possible, and particularly with prototypes, I try to include some form of visual indicator. These indicators can be removed upon completion of the design to limit component count and slightly reduce manufacturing costs.

Table 1 helps to show the state that each

Table 1 Communication Direction Truth Table

Communication Direction	P15 (FMEN)	P14 (FMBS2)	P13 (TMEN)	P12 (TMBS2)
PC to RAMPack B	low	input	n/a	n/a
BS2 to RAMPack B	high	output	n/a	n/a
RAMPack B to BS2	high	output-high	high	input
RAMPack B to G12032	high	output-high	low	input
BS2 to G12032	high	output-high	low	output

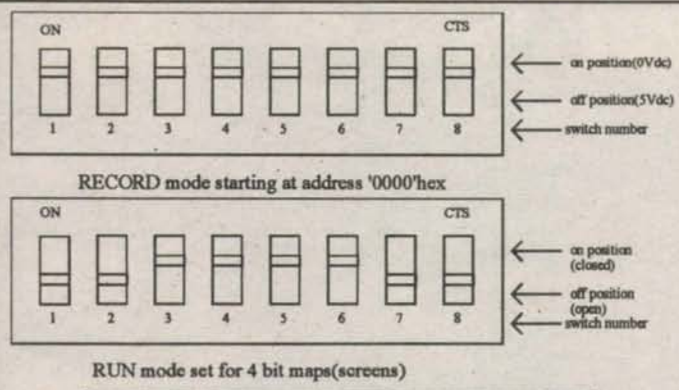


Figure 4 — Dip Switch Settings

individual control line should be in to allow data to follow the desired path in the communication circuit. Additional control lines for the FIFO mode in the RPB should also be addressed, and are discussed in the code examples. You may also review the February '99 Stamp Applications article "Storing Data With The RAMPack B," for a more in-depth discussion of using the FIFO buffer mode in the RPB.

System Functional Description

With the interface circuitry defined, we can now begin to ponder the general system functionality. From the start, we knew that this design would store bit maps received from the PC in the RPB. This same data was to be transferred to the G12032 LCD for display. But some user interface needs to be implemented into the design to allow for ease of use.

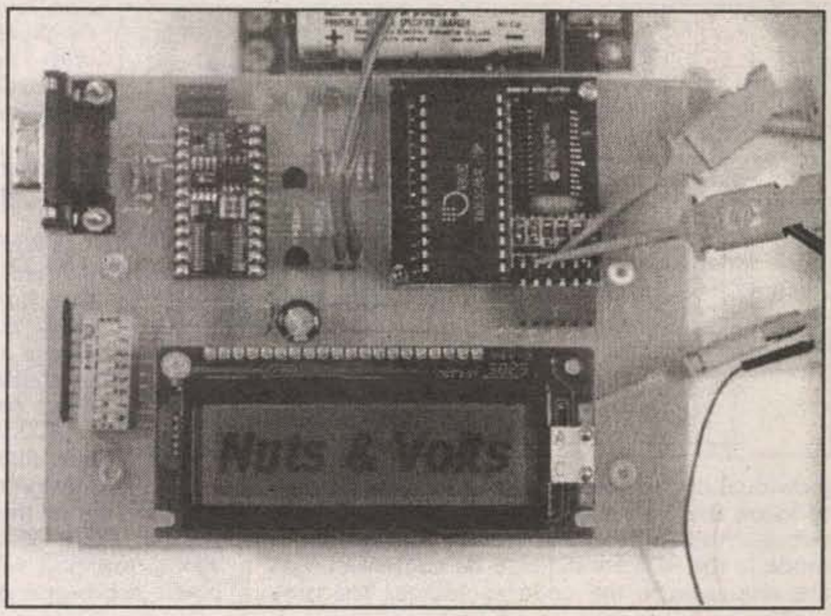
Let's define three modes of operation in this design: RUN, RECORD, and STOP. In RUN mode, the BS2 will send blocks of data, each block representing a graphic screen, to the G12032 LCD. RECORD mode will be used when data from a PC is to be stored in the RPB. Data will be stored as blocks, with each block representing a bit map or screen. The STOP mode will be used to exit RUN mode and enter RECORD mode.

The BS2 will be interfaced to an eight-switch DIP switch. The switch will connect to P0-P7 of the BS2 as shown in Figure 1. Switches 7 and 8 will be used to select between RUN, RECORD, and STOP modes, while switches 1-6 will be used to select addresses to start recording at, or the number of screens to display, depending upon which mode switches 7 and 8 are set for.

Figure 2 displays a functional flow chart that the BS2 program is based on. It's appropriate here to describe how the memory is parsed from the RPB into the G12032 LCD. Each bit map consists of 480 bytes of data. There are three additional bytes of data associated with each bit map sent to the RPB. This means that for every bit map or screen downloaded to the RPB, 483 bytes will be stored. The additional three data

Code Listing 1. LCD_399.BS2 Graphic LCD Code

```
'LCD_399.BS2 — This program is used to control a BS2 based
'device to record bit maps to the RAMPack B and then relay
'them to a Scott Edwards Electronics G12032 Graphics LCD.
'
'Variables used for RECORD mode
RecordAddress   VAR   Word                      'Address to start recording at
RecHigh         VAR   RecordAddress.highbyte
RecLow          VAR   RecordAddress.lowbyte
StopAddress     VAR   Word                      'Address where recording stopped
StopHigh        VAR   StopAddress.highbyte
StopLow         VAR   StopAddress.lowbyte
'
'Variables used for RUN mode
DisplayEnd      VAR   Word                      'Final display address
DisEndHigh      VAR   DisplayEnd.highbyte
DisEndLow       VAR   DisplayEnd.lowbyte
BlockStart      VAR   Word                      'Start address for current screen
StartHigh       VAR   BlockStart.highbyte
StartLowVAR     BlockStart.lowbyte
BlockEnd        VAR   Word                      'End address for current screen
EndHigh VAR     BlockEnd.highbyte
EndLow          VAR   BlockEnd.lowbyte
'
'G12032 Graphic LCD constants
ClrLCD          CON   12                        'Clear LCD command
BLiteOn         CON   14                        'Turn on backlight LCD command
'
'I/O pin lables
FMEN            CON   15                        'FM enable
FMBS2           CON   14                        'FM on BS2
TMEN            CON   13                        'TM enable
TMBS2           CON   12                        'TM on BS2
R_W             CON   11                        'RPB read/write pin
MODE            CON   10                        'RPB FIFO mode select pin
'
'*****************************************************************
Initialize:
        PAUSE  1000                             'Allow time for power up
        HIGH   MODE                             'Normal operation mode
        HIGH   R_W                              'Default to Read mode
        HIGH   FMEN                             'Disable outside serial data
        HIGH   TMEN                             'Disable serial data to LCD
        PAUSE  100
        GOTO   MainProgram
'*****************************************************************
'RECORD MODE: The record subroutine records data from the serial
'input device in the RAMPack B. The DIP switch settings for switches
'1-6 determine where the recording starts at in RAM. While in
'record mode the RAMPack B is placed in FIFO mode. This causes all
'data sent in 8N1 9600 baud format to be stored sequentially in RAM.
'Mutiple screens can be stored in RAM with the software for storing
'bit maps at the "www.seetron.com" downloads website. Debug
'statements are used to indicate the start location of the recording
'and the final location recorded to.
'
RecordMode:
        RecordAddress = INL                     'Find start address from DIP switch
        RecordAddress = RecordAddress&%00111111
        RecordAddress = RecordAddress * 483
        Debug  "StartAddr = ", DEC RecordAddress,cr
        Debug  "recording",cr
        SEROUT FMBS2,84,[$55,$05,RecHigh,RecLow]
        INPUT  FMBS2
        LOW    FMEN                             'Enable outside serial data
        LOW    R_W                              'Place FIFO in write mode
        LOW    MODE                             'Place RPB in FIFO mode
KeepRecording:
        If IN6 = 0 Then KeepRecording           'Stay in FIFO until record ends
        HIGH   MODE                             'Exit FIFO mode
        HIGH   R_W                              'Default to FIFO Read mode
        HIGH   FMEN                             'Disable outside serial data
        PAUSE  10
        SEROUT FMBS2,84,[$55,$07]               'Read end of FIFO pointer
        SERIN  TMBS2,84,[StopHigh,StopLow]
        Debug  "StopAddr = ", DEC StopAddress,cr
        RETURN
'*****************************************************************
'STOP MODE: The stop subroutine checks to see if the RECORD mode
'is requested. If it is not desired then this routine returns to
'the main menu.
'
StopMode:
        If NOT IN6 = 0 Then NoRecordMode
        GOSUB RecordMode
NoRecordMode:
        RETURN
'*****************************************************************
'RUN MODE: The run subroutine makes use of the DIP switches 1-6
'in a manner similar to the RECORD mode. The DIP switches are read
'and from this value the number of screens to display is determined.
'The bit map data is sent to the G12032 LCD in 480 byte blocks.
'When the DisplayEnd variable is equal to the EndBlock variable
'then the RUN routine is exited. In between sending screens to the
'LCD this routine checks for a STOP Mode by testing switch 8. If
'a stop is requested then this routine is exited immediately.
'
RunMode:
        DisplayEnd = INL                        'Read DIP switch
        DisplayEnd = DisplayEnd&$003F           'zero all but switches 1-6
        DisplayEnd = DisplayEnd + 1             '# screens = switch value + 1
        DisplayEnd = DisplayEnd * 483           'Final address = # screens * 483
        BlockStart = 0
        LOW    TMEN                             'Enable serial data to LCD
FrameDelay:
        PAUSE  700                              'Allow time for data to get to LCD
        If IN7 = 1 Then ContinueFrame           'Test for STOP mode
        RETURN
ContinueFrame:
        SEROUT TMBS2,84,[ClrLCD,BLiteOn]
        SEROUT TMBS2,84,[$1B,"DG"]              'Send commands to G12032 LCD
        INPUT  TMBS2
        PAUSE  250
        BlockEnd = BlockStart + 483             'Find end of bock address
        BlockStart = BlockStart + 3             'Bypass stored command bytes
        SEROUT
FMBS2,84,[$55,$02,StartHigh,StartLow,EndHigh,EndLow]
        BlockStart = BlockEnd                   'Update start address
        If BlockStart = DisplayEnd then DisplayDone
        GOTO FrameDelay
DisplayDone:
        PAUSE  550                              'Allow time for data to get to LCD
        HIGH   TMEN                             'Disable serial data to LCD
        RETURN
'*****************************************************************
MainProgram:
        If NOT IN7 = 0 Then NoStopMode          'Test for STOP mode
        GOSUB StopMode
        goto   MainProgram
NoStopMode:
        GOSUB  RunMode                          'Run display
        goto   MainProgram
```



bytes, consisting of ESC, "D," and "G," are generated by the software that Scott Edwards Electronics provides to send bit maps to the G12032 LCD. They represent a command required to download a 480-byte bit map to the G12032 LCD. Also specific to this command is a 200ms pause period that should occur between sending ESC "DG" command and the sending of the 480 bytes of bit map data. With the RPB, we will be using the Block Read command, as well as implementing FIFO Write operations.

It's not possible to have the RPB pause during a Block Read. For that reason, the RPB can not implement the command required by the G12032 LCD appropriately. So, here we are faced with a problem. If the RPB can not send the appropriate command, how can it be implemented? And luckily the solution is readily available. The RPB TM pin is a "pseudo open-collector" configuration. By this, I mean that when it is not transmitting a digital low (0Vdc), it is configured as an input and pulled high by a 1K ohm resistor. For this reason, the BS2 P12 (TMBS2) can act as an input to receive data from the RPB, and as an output to send data to the G12032 LCD.

The solution to our problem is realizable due to the "pseudo open-collector" TM pin and the interface circuitry utilized in this design. While in the RUN mode, the BS2 sends the ESC "DG" command prior to each bit map screen being sent by the RPB. These command bytes are sent via P12 (TMBS2) of the BS2. After a 250ms pause, the RPB Block Read command is requested by the BS2. The RPB then sends the 480 data bytes for each bit map stored to the G12032 LCD. A simple algorithm prevents the ESC "DG" that is stored in the RPB from being re-sent to the G12032 LCD during each Block Read.

The only serious concern here is that the RPB can not be sending data to the BS2 or G12032 LCD while the BS2 is sending data to the G12032 LCD. By adding delays of appropriate length to the BS2 software, this can be assured.

A little discussion of the RPB Block Read command and FIFO mode may shed some light on how this whole design is implemented. When RECORD mode is entered, the BS2 places the RPB in FIFO Write mode. In this mode, all serial data received is stored sequentially in RAM. Bit maps are sent as a three-byte command, ESC "DG," followed by the 480-byte bit map image. How these bit maps are generated is discussed in the next section. Suffice it to say that for every bit map downloaded to the RPB, 483 bytes of data will be stored. With a Block Read command, you can request a block of data to be returned from the RPB. In our case, we are always requesting blocks that are 480 bytes in length. Each block represents a bit map or screen of the LCD.

Downloading Bit Maps to the RPB

There are several steps to take prior to downloading a bit map from your PC to the RPB. For this implementation, we'll use Microsoft Paint. The first thing you'll want to do is set the parameters of the program to the dimensions of the G12032 LCD. In Microsoft Paint, under the Image pull-down menu, select Attributes. Select pixels (or pels) from the units selection. Then select black and white from the colors selection. When this is done, you can set the width of your bit map to 120, and the height to 32. I actually used clip art and sized it in another graphics program. This was then pasted into Paint for touching up. Figure 3 shows two examples of the kind of graphics that can be designed. These graphics took less than five minutes to complete and very few BS2 resources to display.

One last step is required to store the bit maps in the RPB. You should download the file "dragdropbmp.zip"

Figure 5 — BOM for Graphic LCD Interface Design

Part Number	Description	Part	Manufacturer	Distributor
C1	ceramic capacitor	0.01uF	Panasonic	Digi-Key
C2	electrolytic capacitor	47uF @35V	Panasonic	Digi-Key
D1	5.6V zener diode	1N4734	Lite-On/Vishay	Digi-Key
D2	red LED	P363-ND	Panasonic	Digi-Key
D3	red LED	P363-ND	Panasonic	Digi-Key
D4	green LED	P364-ND	Panasonic	Digi-Key
D5	yellow LED	P365-ND	Panasonic	Digi-Key
J1	BS2 program port	WM4202-ND	Waldom	Digi-Key
J2	+5V posts	WM4200-ND	Waldom	Digi-Key
J3	RPB socket	WM3004-ND	Waldom	Digi-Key
J4	DB9-Female	A2100-ND	Waldom	Digi-Key
J5	top entry 0.1" female	WM3206-ND	Waldom	Digi-Key
Q1	NPN transistor	2N3904	National	Digi-Key
Q2	NPN transistor	2N3904	National	Digi-Key
R1	resistor 1/8W 5%	4.7K ohm	Yageo	Digi-Key
R2	resistor 1/8W 5%	1.0K ohm	Yageo	Digi-Key
R3	resistor 1/8W 5%	1.0K ohm	Yageo	Digi-Key
R4	resistor 1/8W 5%	4.7K ohm	Yageo	Digi-Key
R5	resistor 1/8W 5%	4.7K ohm	Yageo	Digi-Key
R6	resistor 1/8W 5%	1.0K ohm	Yageo	Digi-Key
R7	resistor 1/8W 5%	1.0K ohm	Yageo	Digi-Key
R8	resistor 1/8W 5%	1.0K ohm	Yageo	Digi-Key
R9	resistor 1/8W 5%	1.0K ohm	Yageo	Digi-Key
R10	1/9 of 10K SIP resistor	1/9 of Q9103-ND	Panasonic	Digi-Key
R11	1/9 of 10K SIP resistor	1/9 of Q9103-ND	Panasonic	Digi-Key
R12	1/9 of 10K SIP resistor	1/9 of Q9103-ND	Panasonic	Digi-Key
R13	1/9 of 10K SIP resistor	1/9 of Q9103-ND	Panasonic	Digi-Key
R14	1/9 of 10K SIP resistor	1/9 of Q9103-ND	Panasonic	Digi-Key
R15	1/9 of 10K SIP resistor	1/9 of Q9103-ND	Panasonic	Digi-Key
R16	1/9 of 10K SIP resistor	1/9 of Q9103-ND	Panasonic	Digi-Key
R17	1/9 of 10K SIP resistor	1/9 of Q9103-ND	Panasonic	Digi-Key
U1	BASIC Stamp 2	BASIC Stamp 2	Parallax	Digi-Key
U2	RPB connect to J3	RAMPack B	Solutions Cubed	Digi-Key
U3	8 switch DIP switch	CT1948MST-ND	CTS	Digi-Key
U4	8K NVRAM (optional	DS1225	Dallas Semi.	Newark
U5	Graphic LCD module	G12032	Scott Ed. Elec.	Scott Ed. Elec.

SOURCES

For more information on the BASIC Stamp, contact:

Parallax, Inc.
3805 Atherton Road, #102
Rocklin, CA 95765
phone **(916) 624-8333**
http://www.parallaxinc.com

For G12032 Graphic LCD
Scott Edwards Electronics, Inc.
2700 E. Fry Blvd. Suite A4
Sierra Vista, AZ 85635
phone **520-459-4802**
fax **520-459-0623**
www.seetron.com info@seetron.com

For RAMPack B
Solutions Cubed
Lon Glazner
3029 Esplanade Suite F
Chico, CA 95973
E-Mail: **lon@solutions-cubed.com**
Phone: **530-891-8045**
Fax: **530-891-1643**

from "www.seetron.com" in the downloads directory. After unzipping this file set, you will find executable files named "Bmp2com1.exe" through "Bmp2com4.exe." Simply drag the file that relates to the communication port you use for serial data transfer onto your desktop. For instance, I use communication port 2 for testing so I moved "Bmp2com2.exe" onto my desktop. This creates a shortcut to the file that you just moved.

At this point, you can place the system into RECORD mode. To do this, first place the system in STOP mode by setting switch 8 in the "on" position (0Vdc should be present at P7). Next, set switches 1-6 to the screen location that you want to record to. For simplicity, let's set ours to address zero. Next select RECORD mode by placing switch 7 into the "on" position (0Vdc should be present at P6). The RPB should now be in FIFO mode, and will be recording data.

See Figure 4 for DIP switch settings. If you use the schematic in Figure 1, the STOP mode is indicated by a lit yellow LED. The RECORD mode is indicated by both the yellow and green LEDs being lit.

To use the "Bmp2com*.exe" program, simply select your bit map from Windows Explorer and drag it onto the shortcut that you just created. A DOS window will open and tell you if the file was transferred correctly. When asked if you would like to save this image to EEPROM, answer no. Then close the DOS window. If the system is left in RECORD mode, you may continue to load bit maps by repeating the previous steps. Each bit map will be stored one after another in RAM by the RPB.

To enter RUN mode, place the system back into STOP mode and select the number of screens you want to display with DIP switches 1 through 6. Finally, exit STOP mode and the system should begin cycling through the graphics that are stored in the RPB.

When selecting either the screen location to record at, or the number of screens to display, DIP switches 1 through 6 should be read in binary format and one should be added to the result. DIP switch 1 is the least significant bit. For instance, Figure 4 depicts RUN mode with the DIP switch settings for switches 1 through 6 at '000011'binary. This results in screens 1, 2, 3, and 4 being displayed.

In Closing

This design example is just one method of interfacing to the G12032 LCD. Because the G12032 LCD has on-board EEPROM, the use of the RPB as a serial data buffer may be overkill. Then again, if you want to do some limited display animation, or have a requirement for more than eight screens in your graphic display, you may want to take a closer look at this design. Furthermore, this design can be a road map to building all sorts of useful serial data buffers. Storing Global Positioning System (GPS) data, or receiving long serial data strings, can be easily accomplished with a BS2 and an RPB. The RPB comes with static RAM, so in some designs you might consider replacing the static RAM with non-volatile RAM. A non-volatile RAM part is listed as U4 in the bill of materials (BOM) for your reference.

All told, this design utilized only 10 bytes of RAM in the BS2, and six I/O lines to interface to the G12032 LCD and the RPB. Additional I/O lines were used to interface to a DIP switch, but these could be omitted based on other design requirements. There was also a minimal use of program space required to implement this design. All of these factors make room for modifications that could be useful in applications other than the one presented here.

There are plenty of real-world applications for this kind of system. Imagine a restaurant with a graphic LCD on every table. The display could cycle through meal specials, show the soup-of-the-day, and even advertise other local establishments. With a little more design work, the owner could update all of the table top displays through a single PC, on a weekly basis.

For your average BASIC Stamp guru, a pretty cool data logger and serial printer interface could be hammered out of this design. Well, after all is said and done, I hope some of you Stampers found at least a little something new here.

A Gerber file for PCB generation will be located at "www.solutions-cubed.com" in the RAMPack B section of the website. This might be useful to any of you out there who might want to build this graphic LCD bit map recorder. **NV**

Lon Glazner is a partner and engineer at Solutions Cubed. Solutions Cubed is an innovative group of design engineers who specialize in embedded control design. They also produce a line of BASIC Stamp compatible products called Miniature Engineering Modules.

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- HP 86260A-H04 RF Plug-in, 10.0-15.0 GHz, +10 dBm unlevelled — $500.00
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- HP 11590A-001 Bias Network, 1.0-18.0 GHz, APC7 — $450.00
- HP 11692D Dual Directional Coupler, 22 dB, 2-18 GHz — $800.00
- HP 33321K Programmable Step Atten., 0-70 dB, DC-26.5 GHz, 3.5mm — $475.00
- HP 33327L-006 Programmable Step Attenuator, 0-70 dB, DC-40 GHz, 2.9mm — $1,200.00
- HP 774D Dual Directional Coupler, 20 dB, 215-450 MHz — $275.00
- HP 777D Dual Directional Coupler, 20 dB, 1.9-4.1 GHz — $275.00
- HP 778D Dual Dir. Coupler, 20 dB, 100-2000 MHz, N test port — $450.00
- HP 778D-011 Dual Dir. Coupler, 20 dB, 100-2000 MHz, APC7 test port — $450.00
- HP 8431A 2-4 GHz Band Pass Filter, N(m/f) — $150.00
- HP 8470B Crystal Detector, 10 MHz-18 GHz, neg. pol., APC7 — $250.00
- HP 8472A Crystal Detector, 10 MHz-18 GHz, neg. pol., SMA — $150.00
- HP 8472B Low Barrier Schottky Det., 10 MHz-18 GHz, neg.pol., SMA — $200.00
- HP 8494A-001 Step Attenuator, 0-11 dB, DC-4 GHz, N(f/f) — $350.00
- HP 8494G-002 Programmable Step Attenuator, 0-11 dB, DC-4 GHz, SMA — $350.00
- HP 8495H-002 Programmable Step Attenuator, 0-70 dB, DC-18 GHz, SMA — $400.00
- HP 8497K-004 Programmable Step Attenuator, 0-90 dB, DC-26.5 GHz — $750.00
- HP K281C-012 WR42 x APC3.5(m) Adapter — $300.00
- HP K382A WR42 Direct Reading Attenuator, 0-50 dB, 18-26.5 GHz — $2,900.00
- HP K422A WR42 Flat Broadband Detector, 18.0-26.5 GHz — $350.00
- HP K532A WR42 Frequency Meter, 18.0-26.5 GHz — $450.00
- HP K870A WR42 Slide Screw Tuner, 18.0-26.5 GHz — $275.00
- HP K914B WR42 Moving Load, 18.0-26.5 GHz — $300.00
- HP Q752D WR22 Directional Coupler, 20 dB, 33-50 GHz — $650.00
- HP R382A WR28 Direct Reading Attenuator, 0-50 dB, 26.5-40 GHz — $2,000.00
- HP R422A WR28 Crystal Detector, 26.5-40 GHz — $400.00
- HP R532A WR28 Frequency Meter, 26.5-40 GHz — $500.00
- HP R752A WR28 Directional Coupler, 3 dB, 26.5-40 GHz — $450.00
- HP R914B WR28 Moving Load, 26.5-40 GHz — $250.00
- HP V365A WR15 Isolator, 25 dB, 50-75 GHz — $750.00
- HP V752D WR15 Directional Coupler, 20 dB, 50-75 GHz — $650.00
- HP X870A WR90 Slide Screw Tuner — $150.00
- HUGHES 45712H-1000 WR22 Frequency Meter, 33-50 GHz — $900.00
- HUGHES 45721H-1000 WR28 Direct Reading Attenuator, 0-50 dB, 26.5-40 GHz — $900.00
- HUGHES 45732H-1200 WR22 Level Set Attenuator, 0-25 dB, 33-50 GHz — $250.00
- HUGHES 45772H-1100 WR22 Thermistor Mount, -20 to +10 dBm, 33-50 GHz — $400.00
- HUGHES 45775H-1100 WR12 Thermistor Mount, -20 to +10 dBm, 60-90 GHz — $800.00
- HUGHES 47316H-1111 WR10 Tuneable Detector, 75-110 GHz, positive polarity — $600.00
- HUGHES 47323H-1211 WR19 Flat Broadband Detector, negative, 40-60 GHz — $650.00
- HUGHES 47974H-1000 WR15 SPST PIN Switch, 250 MHz speed, 60-62 GHz response — $375.00
- KRYTAR 2616S Directional Detector, 1.7-26.5 GHz, K(f/m)/SMC — $200.00
- M/A-COM 3-19-300/10 WR19 Directional Coupler, 10 dB, 40-60 GHz — $450.00
- MIDWEST MICROWAVE 3537 DC Block, 0.1-12.4 GHz, SMA(m/f) *NEW* — $40.00
- MINI-CIRCUITS ZFDC-20-4 Directional Coupler, 19.5 dB, 1-1000 MHz, SMA(f) — $25.00
- MINI-CIRCUITS ZHL-42 Amplifier, 30 dB gain, 0.7-4.2 GHz, +28 dBm, 15V, SMA — $400.00
- NARDA 3000-SERIES Directional Couplers — $150.00
- NARDA 3024 Bi-Directional Coupler, 20 dB, 4-8 GHz — $300.00
- NARDA 3090-SERIES Precision High Directivity Couplers — $225.00
- NARDA 368BNM Coaxial High Power Load, 500 Watts, 2.0-18 GHz, N(m) — $500.00
- NARDA 3752 Coaxial Phase Shifter, 0-180 deg./GHz, 1-5 GHz — $1,000.00
- NARDA 3753B Coaxial Phase Shifter, 0-55 deg./GHz, 3.5-12.4 GHz — $1,000.00
- NARDA 4000-SERIES SMA Miniature Directional Couplers — $75.00
- NARDA 4245-10 Directional Coupler, 10 dB, 4-12 GHz, SMA(f) — $100.00
- NARDA 4799 Level Set Attenuator, 0-15 dB, 4-18 GHz, SMA(f) — $135.00
- NARDA 5070-SERIES Precision Reflectometer Couplers — $300.00
- NARDA 765-10 10 dB Attenuator, 50 Watts, DC-5 GHz, N(m/f) — $165.00
- NARDA 769-30 30 dB Attenuator, 150 Watts, DC-6 GHz, N — $275.00
- NARDA 792FF Variable Attenuator, 0-20 dB, 2.0-12.4 GHz — $375.00
- NARDA 794FM Direct Reading Variable Attenuator, 0-40 dB, 4-8 GHz — $375.00
- OMNI-SPECTRA 2085-6010-00 Crystal Detector, 1-18 GHz, negative polarity, SMA(m/f) — $50.00
- PAMTECH KYG1014 WR42 Junction Circulator, 18.0-26.5 GHz — $250.00
- SONOMA SCIENTIFIC 21A3 WR42 Circulator, 20 dB, 20.6-24.8 GHz — $75.00
- SPACEK LABS K-2X Frequency Doubler, 9.0-13.25 GHz in/ 18.0-26.5 GHz out — $350.00
- TRANSCO 705C90100 Latching DPDT Transfer Switch, DC-26.5 GHz, 28 V — $150.00
- TRG B528 WR22 Direct Reading Phase Shifter, 0-360 deg.,33-50 GHz — $1,250.00
- TRG V551 WR15 Frequency Meter, 50-75 GHz — $600.00
- TRG W551 WR10 Frequency Meter, 75-110 GHz — $750.00
- WAVELINE 10008D WR28 Terminated Crossguide Coupler, 30 dB — $200.00
- WEINSCHEL 1515 Power Divider, 2-Way, DC-18 GHz, SMA(m/f/f) — $125.00
- WEINSCHEL DS109 Double Stub Tuner, 1-13 GHz, N(m/f) — $150.00
- WEINSCHEL DS109LL Double Stub Tuner, 0.2-2.0 GHz, N(m/f) — $150.00
- WILTRON 60A50-opt.1 SWR Bridge, 5-2000 MHz, APC7, 46 dB directivity — $450.00

COMMUNICATIONS
- HP 4935A-003 Transmission Test Set, 20 Hz-110 kHz, battery power — $600.00
- HP 59401A HPIB Bus Analyzer — $700.00
- TEK 1410R NTSC Gen.,w/SPG2 sync. generator, TSG7 color bars — $800.00
- TEK 1411R PAL Gen.,w/SPG12 sync, TSG11 color bars;TSG13 linearity — $750.00
- TEK 1411R PAL Test Gen., w/SPG12,TSG11,TSG13,TSG15,TSG16 — $1,000.00
- TEK 1411R PAL Test Gen., w/SPG12,TSG11,TSG12,TSG13,TSG15,TSG16 — $1,100.00
- TEK 1411R-opt.04 PAL Test Gen.,w/ SPG12,TSG11,TSP11,TSG13,TSG15,TSG16 — $1,400.00
- TEK 1420 NTSC Vectorscope — $600.00
- TEK 147A NTSC Test Signal Generator, with noise test signal — $800.00
- TEK 148 PAL Insertion Test Signal Generator — $700.00
- TEK 520A NTSC Vectorscope — $750.00
- TEK 521A PAL Vectorscope — $750.00

MISCELLANEOUS
- FLUKE 2625 Hydra Data Logger — $1,250.00
- P.A.R. 5206-95,98 Two-Phase Lock-in Amp., 2 Hz-100 kHz, GPIB — $1,500.00
- P.A.R. 5209 Lock-in Amp., 0.5 Hz-120 kHz, 130 dB dynamic reserve — $2,000.00
- TEK TM5006 5000-series 6-slot Programmable Power Module — $600.00
- TEK TM504 500-series 4-slot Power Module — $175.00
- TEK TM506 500-series 6-slot Power Module — $250.00
- TEK TM515 500-series 5-slot Traveller Power Module — $275.00

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Questions & Answers

TECH FORUM

This is a READER TO READER Column. All questions AND answers will be provided by *Nuts & Volts readers* and are intended to promote the exchange of ideas and provide assistance for solving problems of a technical nature. All questions submitted are subject to editing and will be published on a space available basis if deemed suitable to the publisher. All answers are submitted by readers and *NO GUARANTEES WHATSOEVER* are made by the publisher. The implementation of any answer printed in this column may require varying degrees of technical experience and should only be attempted by qualified individuals. Always use common sense and good judgement!

QUESTIONS

Send all material to **Nuts & Volts Magazine**, 430 Princeland Court, Corona, CA 91719, OR fax to (909) 371-3052, OR E-Mail to **forum@nutsvolts.com**

I have a Bell South cordless telephone, model 820. When the "number" button is pushed, there's a delay before the dial tone is heard. I'd like to shorten this delay as much as possible. Any suggestions?

3991 — **Rod Bowes**
olddog@empire.net
Via Internet

Where can I find a device that will automatically lower the volume of my car radio while my car is not moving?

3992 — **Bernard Glassman**
Washington, DC

I am looking for information on what's known as the screwdriver antenna.

I saw it on a website, but cannot find it again. It is a cylindrical multi-band HF antenna rigged with the motor from a cordless screwdriver for band changing. The author had mounted the unit on his vehicle for mobile work.

3993 — **Kevin KD6LFO**
Via Internet

How can I control the frequency for solid-state induction heaters?

3994 — **Eugenio Lopez**
Via Internet

I am looking to control some fan motors in a building. I planned on using the BASIC Stamp II as the local controller. However, I need to link the Stamp to a central control PC which may be as far as half a mile (inside a building) away. I need to find out if there is any information on linking the Stamp to a modem, or using some other circuitry to make that half mile link.

3995 — **Anonymous**
Via Internet

For a hobby, I rebuild ARC-5 receivers. Often, all that is needed is the replacement of a few leaky capacitors.

I am not familiar with one of the capacitors which the parts list calls a 5 uF 300V non-polarized electrolytic. I am familiar with polarized electrolytics, but not non-polarized ones. Can someone explain what such a capacitor is, what its function is and, perhaps a source for this capacitor?

3996 — **John Broussard**
Breaux Bridge, LA

When I run Windows Explorer on my system, sometimes it shuts down and I get the dreaded blue screen that says, "Fatal Exception Error at... " (Looks like a hexadecimal number, a memory address perhaps?)

What does this mean? How do I interpret these cryptic numbers? How do I make it stop?

3997 — **Lonnie W. Sutton**
Dugway, UT

I currently have a stereo headset with boom mic that interfaces into my computer's sound card. I would like to set up a device that will allow me to use the headset and mic as a telephone headset and a computer headset simultaneously (computer and telephone sound is blended and mic is attached to the phone).

The electronics of the speaker part should be fairly simple. My biggest hurdle is that the telephone (which I am raiding for parts and circuits) uses a condenser mic and the headset mic is not a condenser (I may be wrong).

Also, I am concerned about introducing electrical anomalies that might feed back into unprotected circuitry of my PC. I have seen commercial products that do this for almost $200.00, but I am fairly certain that this can be accomplished with fairly inexpensive components and a little know-how (a little more than I have that is).

3998 — **Ben Miller**
Noblesville, IN

I'm trying to design a data acquisition system for a quarter-mile race car.

I want to monitor spark pulses and vehicle speed from pulses of a magnet and pickup mounted on one of the front wheels. I am trying to record the signals from the parallel port, and write the pulse values to disk with a time stamp.

I need to write to the disk (or memory) every 100 microseconds. Qbasic's timer function appears to have a resolution of 50 milliseconds. Is there a better way to do this in Qbasic or do I have to this in C (which I'm not very good at)?

3999 — **Mike**
Via Internet

I "took a chance" and bought a HP117A VLF receiver/comparator without a manual or the active loop antenna.

I was able to locate a manual on microfiche from Hewlett Packard, but so far am having no luck finding the active antenna that usually comes with it. The antenna is fed 35 VDC from the 117A.

I have just submitted an ad to *Nuts & Volts* for the antenna, but realize my chances are slim.

Does anyone have any line on this antenna or construction details for it? I would appreciate any help. I would be using it to keep my HP5248L "honest" via the 60 KHz standard frequency broadcast. Many years ago, I helped get a setup similar to this going at Hazeltine, but I had the right antenna.

39910 — **Anonymous**
Via Internet

My problem involves an alarm circuit that I wish to add two relays, one for each of two different alarms.

On the circuit board (no schematics available), I have found

ANSWER INFO

- Include the question number that appears directly below the question you are responding to.
- Payment of $25.00 will be sent if your answer is printed.
- In most cases, only one answer per question will be printed.
- Your name, city, state, and E-Mail address, (if submitted by E-Mail), will be printed in the magazine, unless you notify us otherwise with your submission.
- Due to space limitations, we can not reprint the original questions with the answer. The question number and the issue it appeared in are printed above the answer.
- Unanswered questions from a past issue may still be responded to.
- Comments regarding answers printed in this column may be printed in the Reader Feedback section if space allows.

QUESTION INFO

TO BE CONSIDERED FOR PUBLICATION

All questions should relate to one or more of the following:
1) Circuit Design 3) Problem Solving
2) Electronic Theory 4) Other Similar Topics

INFORMATION/RESTRICTIONS

- No questions will be accepted that offer equipment for sale or equipment wanted to buy.
- Selected questions will be printed one time on a space available basis.
- Questions may be subject to editing.

HELPFUL HINTS

- Be brief but include all pertinent information. If no one knows what you're asking, you won't get any response (and we probably won't print it either).
- Write legibly (or type). If we can't read it, we'll throw it away.
- Include your Name, Address and Phone Number. Only your name will be published with the question, but we may need to contact you.

two useful lines that respond when an alarm is sent.

Line A goes high whenever either alarm is sent and, line B which is normally low, goes high for a high temperature alarm, but this line gives a squarewave pulse of about one second CPS for a rising water alarm.

I would like to turn on a relay for high temperature and a different relay for rising water. When the high temperature or rising water situation returns to normal both lines return to their normal low condition at which time the relays should turn off.

The board has five volts available, so I will be using CMOS logic gates, etc.

39911 **Paul**
Via Internet

I would like to run my portable PC off of a 12-VDC battery. I have tried to find the factory auto adaptor, but it seems not to exist anymore. The maker, Northgate Technologies, also seems not to exist. The AC power supply (transforms?) the AC to 18 VDC.

I would like to build a device that would make 12 VDC into 18 VDC, to function as an auto adaptor might. Can someone offer any suggestions as to an economical means of accomplishing this?

I live in a remote location, powered by a generator that is not constant. While the generator is running, I charge batteries that I later use for power when the generator is not running. The battery on the portable does not last more than five minutes, and I would like very much to be able to run the computer independent of the generator.

39912 **Thomas R. Halwachs**
Via Internet

ANSWERS

ANSWER TO #2993 - FEB. 1999

If you are looking for a "Soft-On" function for your lamps, and you also want to increase bulb life, here is the ideal answer to both features.

When 'Edison' lamp bulbs operate, their filament evaporates, causing thin spots on the filament that soon fail. It is well-known that to increase bulb life, you simply lower the voltage below the lamp's normal operating voltage.

A lower voltage allows the filament to evaporate more slowly. (10% lower voltage will double the lamp's life.) If you operate a 120-volt lamp 10% lower, it runs at 108 volts AC, and you don't even notice the difference.

A 12-volt transformer can be used to 'buck' out 12 volts from the 120-volt line to produce the 108 volts.

For the ultimate answer: Wire two equal wattage lamps in series, so each one operates at 60 volts. This way, they only draw 25% of normal power, so 100-watt bulbs run ~25 watts, and they exhibit a "Soft-On Glow" that is wonderful. They light, but they are not 'incandescent,' and the filament does not evaporate at all.

A group of eight 100-watt lamp bulbs in a bathroom fixture above the mirror has their original bulbs for 18 years, and they still light perfectly. They could last indefinately.

Joe Kish
Clackamas, OR

ANSWER TO #2992 - FEB. 1999

Yes, most projects do not specify whether they need series or parallel crystals. Furthermore, the markings on a crystal often specify only the frequency, so you cannot tell the intended use by looking at it. The good news is that either crystal will work when frequency accuracy is not critical.

Series and parallel crystals are made the same way, but they are tuned differently. The resonant frequency of the crystal is slightly affected by the load placed across its terminals. The oscillator circuit determines that load.

Circuit designers and crystal manufacturers have an agreement. The designer builds his circuit to have a known load (e.g., 20pF), and the crystal maker tunes the crystals to the resonant frequency (say within 50ppm) when the crystal has that load (20pF) across it. If the circuit presents a different load (e.g., 10pF) or a crystal with a different loading parameter is used, then the frequency might be off 200ppm or more.

High impedance oscillator circuits specify crystals with a parallel load capacitance (typically 15 to 30pF). Low impedance oscillator circuits use the fundamental short-circuit resonance of the crystal, so they do not need to specify the load capacitance.

When a 15pF parallel resonant crystal is used, the designer should put a 15pF load across the crystal. That does not mean putting a 15pF capacitor in parallel with the crystal; the design must consider stray capacitance, amplifier input capacitance, and the capacitors in the circuit.

For example, many oscillators use two capacitors — one from each crystal terminal to ground. From the crystal's perspective, these capacitors are in series and need to be 30pF each to place a 15pF load

TECH FORUM

across the crystal.

Accounting for a few pF of stray capacitance on the driven side of the crystal turns one value into 27pF. The amplifier input might have 12pF of input and stray capacitance, so the second 30pF capacitance becomes 18pF.

Other values are possible. The best oscillator circuits use series resonance, and the Pierce oscillator circuit is very common. But there is a catch: Even though the circuit looks like a Pierce and the designer calls it a Pierce, that doesn't mean you should use a series resonant crystal! Many IC- based crystal oscillators don't have the low impedances or the gain to make a true Pierce, so they operate more like parallel oscillators and need parallel-specified crystals.

A reasonable text is Robert J. Matthys, *Crystal Oscillator Circuits.*

Gerald Roylance
Mountain View, CA

ANSWER TO #19914 - JAN. 1999

Your Jeep Cherokee probably uses the OBD II spec onboard computer. You didn't tell us what year it is, but all 1996 models and later are federally required to have OBD II onboard. One of the devices that will tap the OBDII connector is http://www.bb-elec.com/product.asp?dept%5Fid=25&sku=AT1

It is not cheap at $250.00, but it seems to do all that you need. For more info, see http://www.obdii.com or call **B&B Electronics** at **815-433-5100**.

Kasey Chang
San Francisco, CA

ANSWER TO #19912 - JAN. 1999

It sounds like you are looking for a simple 10x10 matrix display driver using LEDs for the pixel elements.

Depending on what the current configuration is, there could be something simpler. But it would still require some form of micro-controller to convert some form of data input and provide a refresh.

First, arrange the LEDs such that the first row of cathodes are tied together and then to the drain of MOSFET R1. Do the same for subsequent rows for MOSFETs R2 through R10. (MOSFETs are nice to use since they do not need current to turn on the switch.) The sources for R1 through R10 are tied to ground.

Next, arrange the first column of anodes such that they are all tied together and then through a current limiting resistor and then to the source of a MOSFET CA. Continue with the other columns for MOSFETs CB through CJ. The drains of these MOSFETs are tied to a high voltage, say 10V.

If you also are looking for a method to dim the display, you can look into Toshiba's constant current drivers such as the TB627 — this would require a different LED connection than that above.

The final step is to drive the display. This is typically accomplished by selecting one row at a time and then turning on the appropriate column driver to light the pixels. The next row would be selected and again the appropriate column drivers are turned on. This is repeated for every row — a frame cycle.

To minimize flickering, there would be at least 60 frames per second. This task is, unfortunately, done with some sort of micro controller.

The good news is that it can be done with some creative programming with a PIC or STAMP.

The rows, since only one is addressed at a time, could use four bits (use 0000 to turn off the row drivers while reloading column data). The column, using a serial-to-parallel shift register, would require two bits.

Derek Koonce
San Jose, CA

ANSWER TO #19911 - JAN. 1999

I have a 1979 Analog Devices catalog supplement that lists the AD2038 as a "6 Channel Scanning Digital Thermometer." There are descriptions of the connector signals, but without pin numbers.

However, the 1978 full catalog lists a AD2036 device with the same name and has the full connector pin numbers. Maybe the two models use the same pinouts.

Ralph Goff
Placentia, CA

ANSWER TO #1997 - JAN. 1999

All the equations you need to get started can be found on the web pages linked from this one. http://www.pa.msu.edu/courses/1997spring/PHY232/lectures/magforces/index.html. They will give you forces in Newtons. 100 lbs. is a weight, which is not the same as a force, but in any event you want to create a magnetic force of 444.822 Newtons, if you choose to go that route. I think the anti-gravity idea is the way to go, however.

Information on Finnish Experiments in anti-gravity can be found here: http://www.artbell.com/roscrash.html, another source of anti-gravity information is http://www.geocities.com/Area51/3066/index.html. But the most compelling information I have seen is from: http://desertblast.antfarm.net/bob2.html

Tom Tillander
Bay Village, OH

ANSWER TO #1995 - JAN. 1999

The tone is likely a sub harmonic of the clock in the counter. The first thing to look for is the frequency counter and radio on the same power source. So look at isolating the power sources to each device with I/C filters (choke and capacitor) or look to see if the power supply may

Continued on page 76

HAM GEAR FOR SALE

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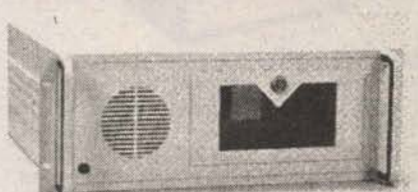

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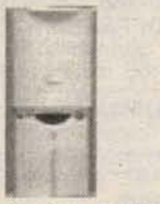

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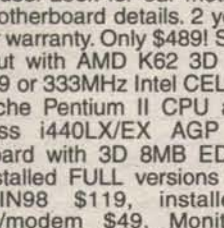

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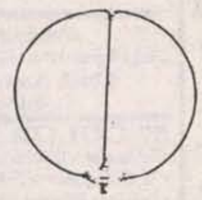

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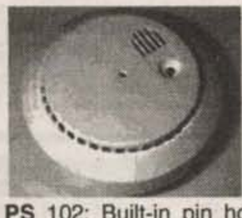

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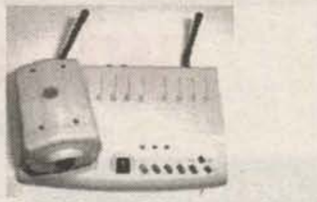

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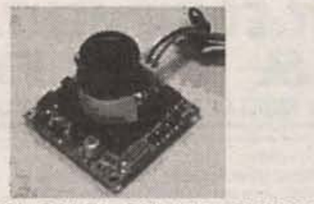

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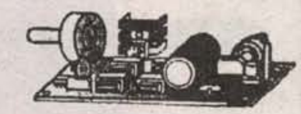

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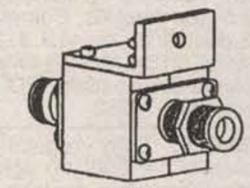

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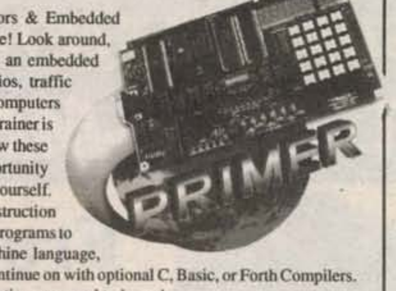

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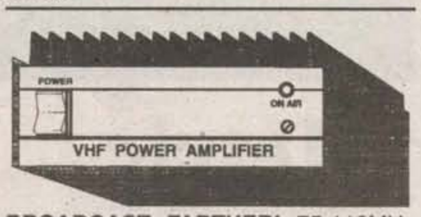

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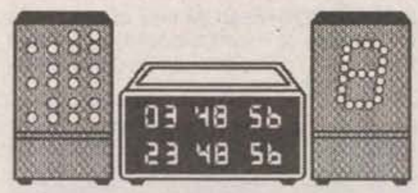

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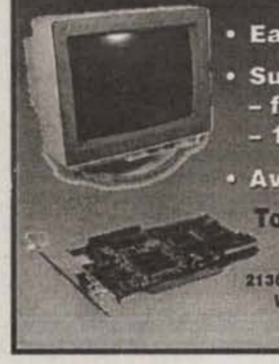

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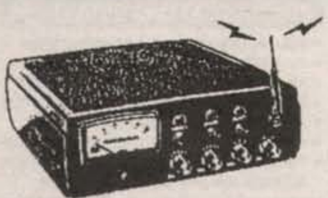

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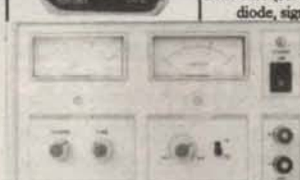

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by Ray Marston

THE 'OPTO' IN OPTOELECTRONICS (Part 1)

Ray Marston explains the basic nature and behavior of light and mirrors in this opening episode of this opto-electronics-related four-part series.

The word 'optoelectronics' first came into general use in the 1970s. The word roughly describes the branch of electronics that is concerned with the practical application of light-related optical (opto) phenomena, and with traditional optical devices such as mirrors, prisms, and lenses, and with modern optical devices such as fiber optic cables, LEDs, and lasers.

Most readers of this magazine will have few problems in understanding the purely electronic aspects of optoelectronics, but probably have very limited knowledge of its optical parts. This new four-part series aims to help remedy the latter situation by giving fairly concise descriptions of vital optoelectronics-related 'opto' subjects.

This opening episode deals with the basic nature and behavior of light, and with mirrors. Part 2 will deal with prisms and lenses. The final two episodes will deal with fiber optic communication and with LED and laser operating principles.

LIGHT

Light is a form of energy and is transported by electromagnetic radiation. It has an apparent dualistic nature that enables it to be regarded as both a wave phenomenon and as a flux-like flow of sub-atomic particles known as *photons*, which are released as a consequence of shifts in the energy levels of atoms, such as those caused by heating or various other disturbences.

All active (moving) photons are endowed with parameters such as frequency (f), velocity (v), *free-space* wavelength (λ), and mass, and thus represent a finite unit of energy (e). In pure physics, the photon's energy, in joules per second, is usually defined by the formula

$$e = h \times f$$

in which h is Planck's constant (= 6.626×10^{34} J s).

In optoelectronics, it is more useful to define the energy in terms of electron-volt (eV) units, and to relate it to the photon's wavelength (λ) in nanometers (nm) rather than its frequency. In this case, the basic formula transforms into the easily remembered form

$$eV = 1240/\lambda$$

Thus, an LED that generates a red output at a wavelength of 645nm has a bandgap energy value of 1.92 eV. The energy value of an individual photon depends on its actual wavelength, but is very small; an ordinary green LED, for example, generates an output flux flow of about 2,500 million photons per microsecond at a mean light output power level of a mere 1mW.

Figure 1 shows a simple conceptual diagram that illustrates some basic features of light when radiated from a small point source. The light flux (which contains vast numbers of photons) is effectively radiated in the form of a continuous series of spherical photonic waves that become progressively more planar (less sharply curved) as they move further from the source.

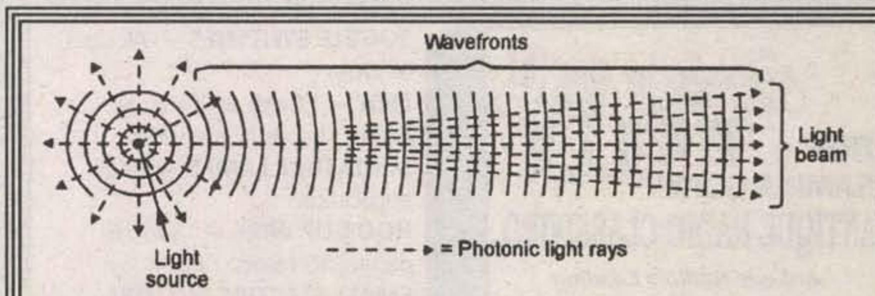


***Figure 1.* Conceptual diagram illustrating some basic features of radiated light.**

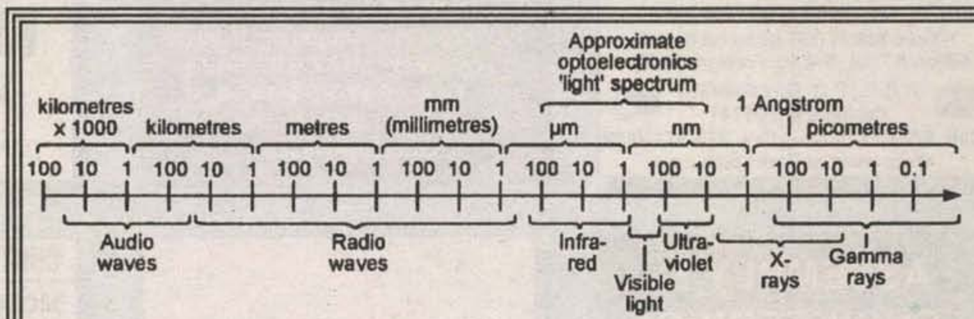


***Figure 2.* The full electromagnetic spectrum (wavelengths are given in decade multiples and submultiples of the meter).**

The photons move outwards, perpendicular to the wave fronts; a photonic light *ray* traces the mean path of a photon, a photonic light *beam* depicts the paths of a collection of rays. A light beam is angular when close to the light source, but becomes progressively more parallel as the distance from the source increases.

In optoelectronics, the term 'light', relates to the entire visible light (400nm to 700nm) part of the electromagnetic spectrum, plus most of its invisible infrared (IR) and ultra-violet (UV) ranges, i.e., to the spectrum's 10nm to 100μm section. *Figure 2* shows details of the full electromagnetic spectrum, and *Figure 3* shows the so-called 'visible' part of the spectrum. All wavelengths are marked in decade multiples and submultiples of the meter.

The sun is the most powerful light generator in our solar system. It generates and radiates light ener-

gy as a byproduct of its continuously-active nuclear fusion process; 60% of its radiant energy lays in the IR range. Only 0.0005% of the sun's radiated energy is (after travelling a mean distance of 93 million miles through space in 8 minutes 20 seconds) received by planet Earth, and one third of this reflects directly back into space. The energy contained in the remaining flux delivers a mean power of 4KW per square meter per day to the earth's surface, and acts as the engine for our planet's weather systems and (as a consequence of the results of photosynthesis, etc.) sustains all life on our planet.

Light travels through empty space at a velocity of 186,282 miles (299,792 kilometers) per second. Light's velocity was first *estimated* with reasonable precision by the Danish astronomer Ole Roemer in about 1690, after he observed unexpected variations in the actual and predicted times of the eclipse of Saturn's moons.

The velocity of light through the earth's atmosphere (which is 0.03 percent slower than through empty space) was first *measured* with reasonable precision (within five percent) by the French amateur scientist Armand Fizeau in Paris in 1849.

Fizeau used an opto-mechanical stroboscopic technique to measure the time (about 57µS) that a beam of light took to cover a two-way, 17km journey and, from the results, estimated the speed of light at 313,300 kilometers per second.

THE VISIBILITY OF LIGHT

A stream of light (photons) racing through empty space can be regarded as a stream of latent energy, and is quite invisible; it only becomes visible when its flux strikes an absorptive material and releases some or all of its latent energy. These effects can be observed by looking up at the moon on a clear night; parts of its surface are illuminated because they are absorbing energy from the rays of the sun, which is out of sight below earth's horizon; the areas of space through which the sunlight is travelling appear completely dark.

If you go out into the open air on a bright summer's day, you will be bombarded by a stream of solar-generated IR, UV, and visible light rays that will produce three distinct types of physiological effects on you. The IR rays will produce a sense of warmth wherever they strike exposed areas of your skin, and the UV rays will slowly start to change your skin's pigmentation in those exposed areas, eventually giving them a deep tan. The visible light rays from the sun span the full color spectrum. When they strike an object that you can see, the object's visual coloring is dictated by the object's spectral characteristics.

If the object that is exposed to the sun's light absorbs all of the spectrum's light energy, the object appears black. If it absorbs only part of the available energy and reflects the rest, it will appear white if it reflects light equally across the entire spectrum, or red if it reflects mainly the red part of the spectrum, or green if it reflects mainly the green part of the spectrum, and so on. The apparent colors have degrees of purity that depend on the width of the reflected part of the spectrum.

Note that human eyes do not have a linear spectral response (just as our ears do not have a linear aural response) and the response varies between individuals. The graph of *Figure 4* shows the spectral response of typical human eyes, which are 10 times more sensitive to yellow-green (560nm wavelength) than they are to mid-blue (470nm) or mid-red (660nm).

You can observe these effects by looking at a stained glass window (from within a building) when the window is brightly illuminated by the sun; the window's glass segments all have roughly similar values of translucence, but the green segments seem far brighter than the mid-red or blue ones. The next section of this article gives more details on this subject.

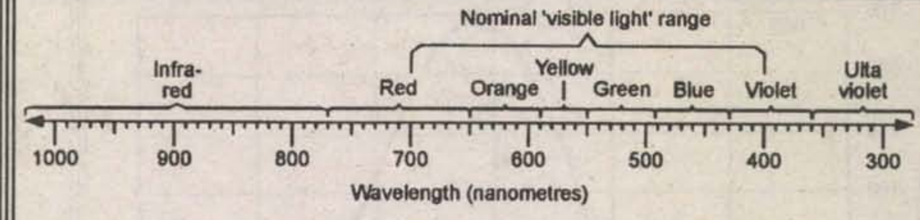


***Figure 3.* The visible light part of the spectrum (wavelengths are in nanometers).**

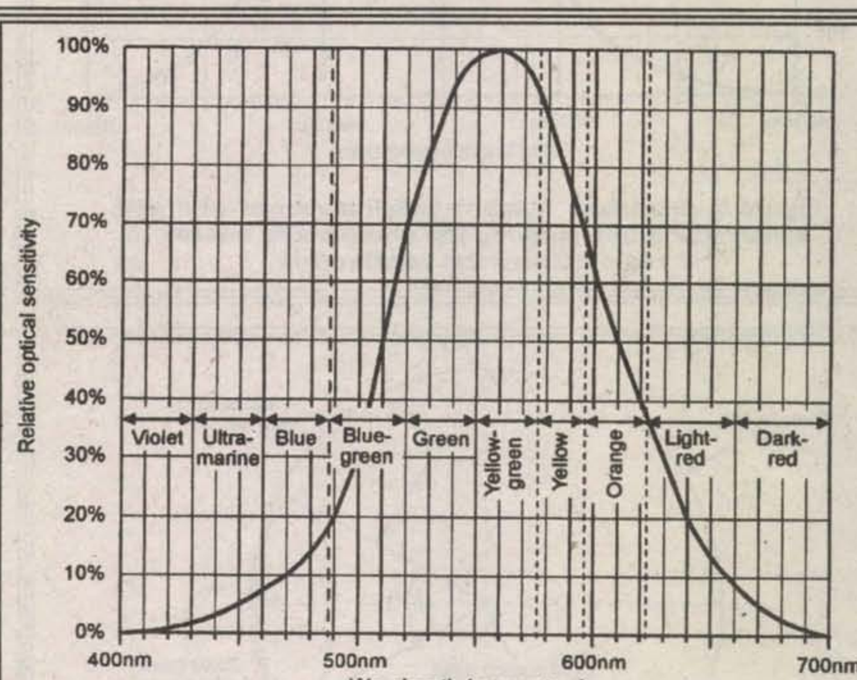


***Figure 4.* Standardized relative spectral response of the human eye.**

LIGHT UNITS

When dealing with light and optoelectronic components such as LEDs and lasers, etc., the units most often used in data sheets are those relating to the light's wavelength and spectral bandwidth, and to the intensity and power levels of its flux. Light *wavelength* is a measure of the light's color; visible-light wavelengths fall within the range 400nm to 700nm; UV-light has a wavelength below 400nm; IR-light has a wavelength above 700nm.

The color purity of a light is defined by its *spectral bandwidth*, which is measured between the points where the radiated power falls to half of its peak value. True white light contains all the colors of the 400nm to 700nm spectrum; it thus has a bandwidth of at least 300nm and is known as *chromatic* (multi-toned) light.

Red LEDs (operating at about 650nm) have typical spectral bandwidths in the range 15nm to 50nm and are thus also chromatic, since their light outputs span various shades of red.

Laser-generated light usually has an exceptionally narrow bandwidth (often less than 0.01nm), and is known as *mono-chromatic* (one-toned or pure-toned) or (if all of its emitted photons are in phase) *coherent* light.

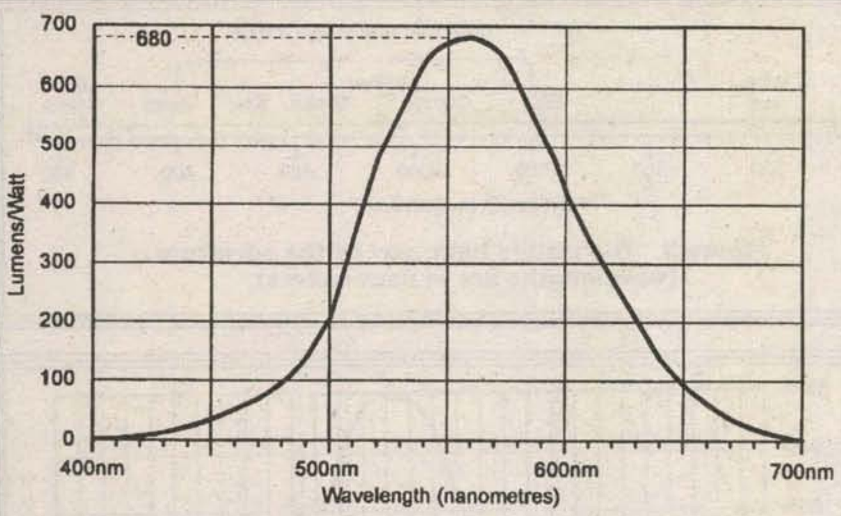


Figure 5. **Standard 'human eyeball response' photopic conversion graph showing the photometric lumens to radiometric watts relationship.**

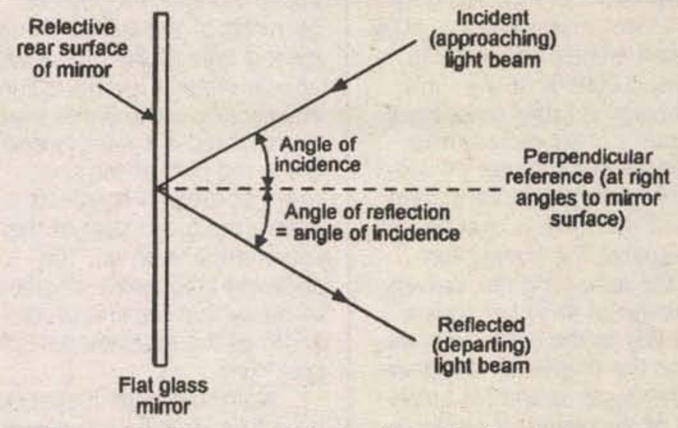


Figure 7. **Diagram illustrating the basic law of reflection that applies to a flat mirror.**

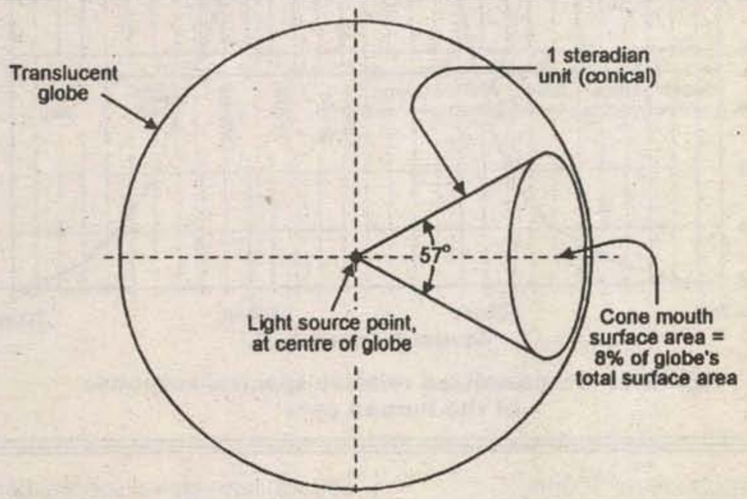


Figure 6. **Conceptual diagram illustrating the basic features of a steradian unit.**

Dealing next with the light units concerned with values of light intensity and power, it is important to note that – since human sight does not have a linear spectral response – these values may be expressed in two different types of unit. Conventionally, *photometric* units are used if they relate to the physiological (apparent) values of visible light sensed by humans, and *radiometric* units are used if they relate to genuine (true) values of visible or IR or UV light. The following four basic types of unit (each of which has both photometric and radiometric notations) are widely used in optoelectronics.

TOTAL RADIATED FLUX POWER

Light is radiated energy; the total power of the flux flowing from a light source is measured in watts in radiometric notation, or in lumens in photometric notation. The photometric quantities are related to the corresponding radiometric ones by the internationally-recognized standard 'human eyeball response' photopic conversion graph shown in *Figure 5*, which shows that one watt of light power is equal to 680 photometric lumens at a wavelength of 555nm (yellow-green), or roughly 82 lumens at 475nm (mid-blue), or 65 lumens at 660nm (mid-red), and so on.

FLUX DENSITY

In most practical optoelectronic applications, only a small fraction of a light source's total radiated power falls on a targeted light receptor such as a photocell or an eye's retina and, in such cases, the most relevant parameter is the light's flux density (brightness) at the actual target point.

In radiometric notation, this parameter is known as the light's *irradiance* value and is measured in watts per square meter (W/m²). In photometric notation, the parameter is known as *illuminance* and is measured in lumens per square meter (lm/m²) or 'lux.' The lumen/watt relationship is the same as that shown in *Figure 5*.

ANGULAR FLUX INTENSITY

Man-made light generators such as LEDs and filament lamps act like crude 'point' light sources, but produce directional outputs, i.e., most of their available flux is concentrated into a cone of radiation. To specify flux intensity in such cases, a standard three-dimensional angular unit known as a steradian (symbol sr) is used; in radiometric measurements, angular flux intensity is known as *radiant intensity* and is specified in units of watts per steradian (W/sr); in photometric measurements, angular flux intensity is known as *luminous intensity* and is specified in units of *candela*, in which one candela equals one lumen per steradian (lm/sr).

Figure 6 shows a conceptual diagram that illustrates the basic features of a steradian unit. Imagine here that a point source of light is set at the center of a translucent globe. From the point source, form a 57° cone that reaches out to the surface of the globe. This cone is a three-dimensional angular unit known as a steradian; the surface area of its mouth encompasses approximately 8% of the globe's total surface area.

RADIATED FLUX BRIGHTNESS

The brightness of a light source is proportional to both the radiated

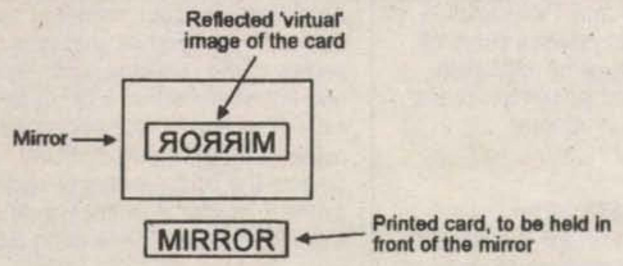


Figure 9. **The image reflected by a simple mirror is reversed, left-to-right.**

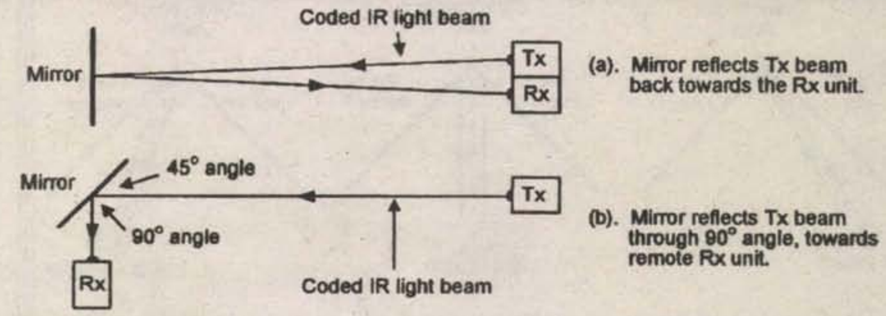


Figure 8. **Two simple ways of using mirrors in optoelectronic security applications.**

flux density and the radiating surface area of the light source. In radiometric notation, this parameter is known as the light source's *radiance* value and is measured in watts per steradian per square meter (W/sr x m²) of radiating surface area. In photometric notation, the parameter is known as *luminance* and is measured in lumens per steradian per square meter (lm/sr x m²) or candela per square meter (cd/m²).

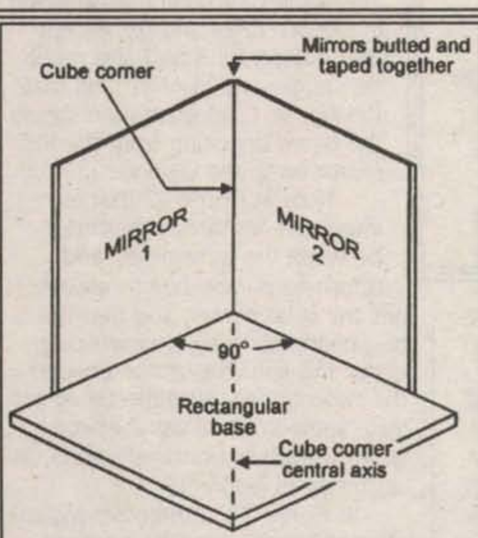


Figure 11. **Basic construction of a simple 'cube corner' retroreflector.**

LIGHT-BEAM MANIPULATORS

Visible and IR light beams can readily be reflected, bent, or manipulated in various other geometric ways with the aid of simple optical devices such as mirrors, retroreflectors, prisms, or lenses. This next section — and the whole of next month's episode — describes the basic operating principles and optoelectronic applications of such devices.

MIRRORS

The simplest mirror is the ordinary flat totally-reflective silvered-back glass type. If a narrow beam of light is aimed through the glass and onto the reflective (rear) surface of such a mirror, the reflected beam always obeys the basic *law of reflection*, which is illustrated in *Figure 7*, and states that the angle of incidence (the angle between the arriving ray and an imaginary line drawn perpendicular to the mirror's surface) and the angle of reflection (the angle between the reflected ray and the imaginary perpendicular line) are exactly equal.

Figure 8 shows two simple ways of using a mirror in optoelectronic security applications. In *Figure 8(a)*, the mirror is used in a corridor protection system, to link a coded Tx IR light beam into an adjacent Rx unit, which activates an alarm if the beam is interrupted.

In *Figure 8(b)*, the mirror is angled at 45° and projects the Tx beam around a 90° corner and on to a remotely-placed Rx unit; this system can be used to protect an L-shaped corridor or two adjoining outside walls of a building, and is aligned by aiming the Tx beam directly at the mirror's Rx image.

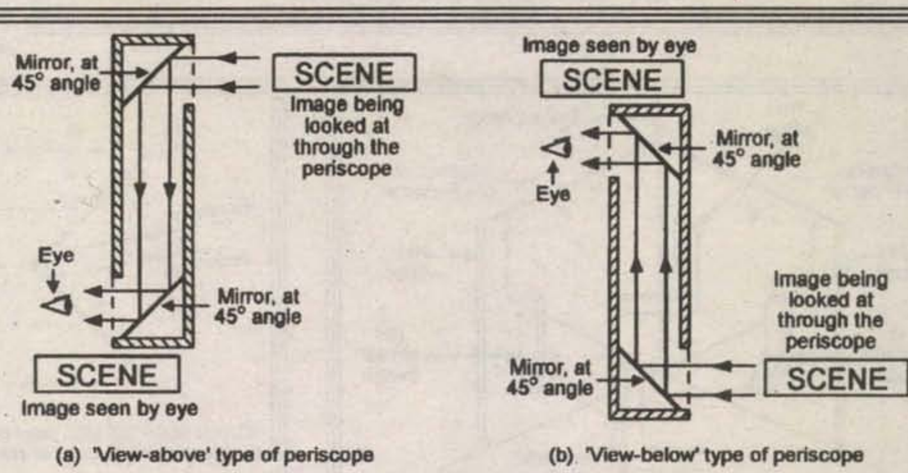
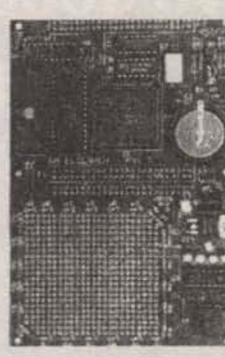


Figure 10. **A periscope presents a genuine (rather than 'virtual') image of a viewed scene.**

Note that the image reflected by a simple mirror is reversed, left-to-right, as shown in *Figure 9*. If you take *Figure 9* and hold it in front of a mirror, you will see that all of its text is reversed in the reflected image, which is thus known as a 'virtual' (rather than real) image. While you are standing in front of the mirror, scratch your right ear; you will see that your virtual image is scratching its left ear.

If a mirror's reflection is viewed in a second mirror, the image that appears in the second mirror becomes real, rather than virtual. Try standing sideways in front of a large mirror, with a small mirror in your left hand; use the small hand mirror to view your image in the large mirror, and scratch your right ear; note that your image also scratches its right ear, but that if you look at your virtual images directly in either mirror, it is the left ear that is being scratched.

One of the most common applications of the above two-mirror technique is in simple periscopes, as illustrated in *Figure 10*. *Figure 10(a)*



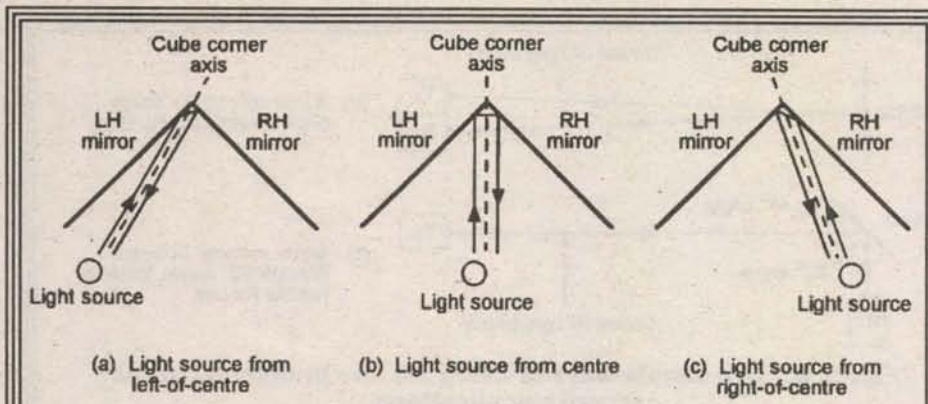


***Figure 12.* Diagram illustrating the functional operation of the cube corner retroreflector.**

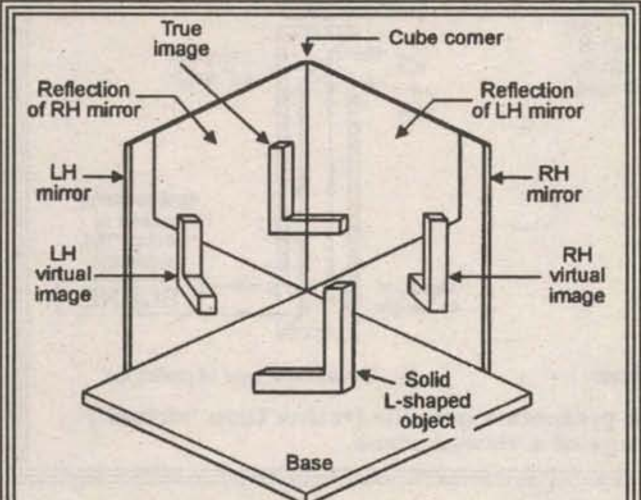


***Figure 13.* When viewed in frontal elevation, this retroreflector produces three images of an object.**

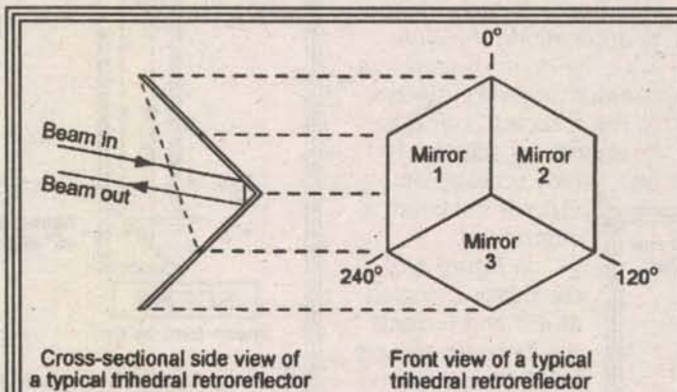


***Figure 14.* Basic construction of a trihedral retroreflector.**

shows the basic construction of a conventional 'view-above' type of periscope. Here, the light from the scene that is being viewed strikes the upper mirror, is reflected downwards at an angle of 90°, and strikes the face of the lower mirror, which bends the light through another 90°, where it can be viewed by the eye of the observer. The resulting image is real, rather than virtual, and is seen from a perspective above the viewer's eye level.

The 'view-above' periscope of *Figure 10(a)* can be used as a 'view-below' type by turning it upside-down, as in *Figure 10(b)*. View-below periscopes are often used in the movie and TV industries to obtain ground-level shots of small animals or of miniature (model) towns or battle scenes, etc., for use in various films/videos.

RETROREFLECTORS

A retroreflector is a passive device that automatically reflects a light's radiation back towards its source, irrespective of the light's precise angle of incidence. Devices of this type are widely used in reflective opto-electronic light-beam security alarms and barrier control systems, and do not have to be precisely aligned with the light-beam source.

Figure 11 shows a way of using two small mirrors (or mirror tiles) to make a device known as a cube corner retroreflector. The two mirrors are simply butted and taped together and set at an angle of 90° degrees by pressing them against the edges of a rectangular base (such as a soft-cover book).

If a light beam (or image) is aimed into the cube corner of this device from any point that is at right angles to the cube's vertical plane, and anywhere within ±35° of its central corner axis on the horizontal plane, the device automatically reflects the light (or image) back towards its source point. *Figure 12* illustrates the unit's operating principle.

In *Figure 12(a)*, the light beam is projected from a left-of-center source towards the retroreflector's corner, hits the LH mirror at an incident angle of (say) 75°, is reflected off again at 75°, hits the RH mirror at an incident angle of 15°, and is reflected off again at an angle of 15°, and heads back towards the source on a parallel path.

The light beam's total angular change is equal to the sum of the two incident and two reflection angles, and inevitably equals 180°. This same basic action is obtained in *Figures 12(b)* and *(c)*, except that different incident and reflection angles are involved and that the *Figure 12(c)* illustration shows the beam bouncing from the RH mirror on to the LH one.

Note in *Figure 12* that an imaginary line drawn centrally between the transmitted and returning parallel beams always hits the cube corner, and that the two beams thus lay symmetrically about this line. This action enables the cube corner retroreflector to produce some unusual visual effects when viewed in frontal elevation, as illustrated in *Figure 13*.

In *Figure 13*, a three-dimensional, solid L-shaped model is turned around so that it is facing the retroreflector and is placed in front of its cube corner. Note that the LH mirror reflects the RH mirror, and vice versa, producing a 'mirror cube' reflection. The retroreflector produces virtual images of the object in both the LH and RH mirrors, and produces a true image of the object in the mirror cube.

The cube corner unit gives only one-dimensional (horizontal plane) retroreflection. An alternative design is the trihedral unit, which gives two-dimensional (vertical and horizontal planes) retroreflection of light beams.

Figure 14 shows the basic construction of this unit, which uses three diamond-shaped mirrors set at 120° to each other; the unit's action is such that a light beam entering its front is reflected through 180° in two dimensions by the mirror surfaces and then returns towards the source point on a parallel path.

Often, hundreds of miniature retroreflectors of this basic type are used in road-side signs, making them glow brilliantly in the headlights of passing vehicles.

Next month's episode of this series will describe the action and applications of prisms and lenses. **NV**

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Part 2

by Mike Keryan

Transmit data from up to eight monitoring stations on your house's power line, and receive the information on your PC.

Connecting the Sensors to X10

In Part 1 of this article, we constructed a circuit on a small (2.5 x 3.5 inch) printed circuit board that samples the ambient temperature and humidity.

The THX10 circuit communicates the information to humans by way of blinking a single LED. It also communicates the information in the form of an eight-bit binary code to an X10 transmitter that broadcasts it onto your house's power line. Up to eight of these transmitters can be placed throughout your house.

Somewhere in your house, a PC connected to an X10 receiver, collects the data, displays it, and produces listings for all the remote devices. The monitoring software is written in BASIC, so it is easy to customize for your own use.

The X10 Transmitter

When designing this system, it was difficult to decide which type of transmitter to use. Most circuits that communicate to X10 use a $25.00 TW523 interface. Since I wanted to have eight remote units, the thought of $200.00 just for the transmitters seemed a little out of line.

I settled instead on the cheaper ($10.00-$15.00) X10 mini controller. You can find the mini controller sold in large hardware stores, at RadioShacks, or through home automation catalogs. The same unit is sold under the names of X10 Powerhouse, Stanley, RadioShack, and no doubt many more.

The cases may look slightly different, but internally they are identical. They have six rocker-type switches; pushing down on the top part of a switch sends an 'on' signal while pushing the bottom sends an 'off' signal.

The first four switches are for channels 1-4 or 5-8 (a little slide switch selects the 1-4 or 5-8 groups); the fifth switch is for dim/bright, while the sixth switch is for all on/all off.

On the left side above the first switch is a LED that glows when a signal is being transmitted. On the right side above the last switch is a rotary switch that sets one of 16 house codes.

The THX10 circuit contains two optoisolated integrated circuits. To send an 'on' or 'off' sequence to the mini controller, NPN transistors within the ICs are turned on by a pulse sent from the PIC CPU. These transistor outputs, acting like switches, are wired in parallel with the corresponding switches in the mini controller. When the mini controller broadcasts the signal onto the power line, it includes house and channel number information in the coded signal, so the receiver can determine who sent it.

For my remote units, I used only the PC board and the connected AC line cord from the mini controller; I tossed away the plastic case and all the plastic switches. I attached a small 12-volt transformer to the AC in the mini controller to power the THX10 sensor circuit. The two PC boards connect together via a five-conductor cable — two wires for the 12-volt AC and three wires for the X10 logic signals. Both PC boards were then mounted in the same case (note below that they must be thermally isolated), making a fairly compact (4.5 x 8 x 1.25 inch) unit.

The X10 mini controller is easy to interface and most home experimenters should be capable of handling the job. However, precautions should be taken when the unit is plugged into the AC line. The mini controller circuit uses no isolation transformers, so the circuit is at 117-volt potential when it is plugged in. **NEVER work on or touch anything on the board when line voltage is present!** The THX10 circuit is adequately isolated from the AC; the three logic lines are passed to optoisolator ICs, while the 12-volt AC is isolated by way of the transformer T1.

When working on the mini controller board, the first thing you should do is decide which house code and channel number is required. All of the remote units must be set to the same house code, while every one of them must be set to a different channel. Photo 1 shows what I call the bottom of the board — the side with the soldering (in the mini controller case, it is really the top side).

The house code is set by what's left of the rotary switch in the upper right corner. A small solder blob across the three switch contacts as shown will decode to house code 'F.' If you desire a different house code programmed, try to figure out which contacts would be connected together by the switch, and solder some small jumper wires onto the PC board contacts. A small blob of solder is also needed to select either the '1-4' or '5-8' channel groupings.

For the first unit, solder across the two terminals at the left, as shown near the bottom of the board. When constructing a unit for channels 5-8, put a blob across the center and the right terminal, instead.

The other side of the PC board is shown in Photo 2, what I call the top side. Here, I cemented the trans-

Photo A. The mini controller X10 transmitter (still in its plastic case) on the left, and the CM11A X10 receiver on the right.

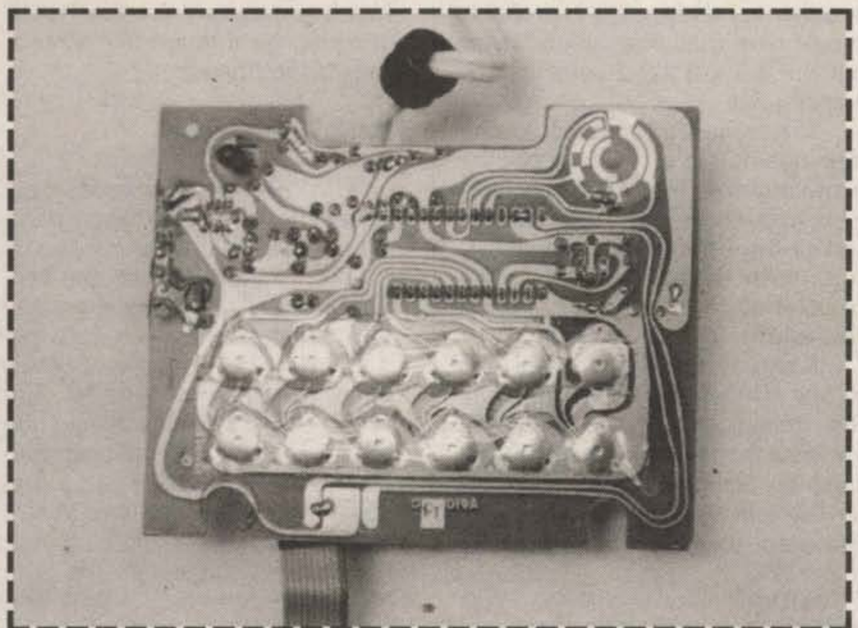

Photo 1. Bottom (foil) side of the mini controller PC board.

former T1 into the large open area at the bottom using a glue gun. Note that the terminals are upward to make it easy to solder wires to them.

The two black wires on the top side of the transformer (pins 1 and 5) are fed through two pre-existing, unused holes to solder pads on the other side to pick up the 117-volt AC. The one at the left (AC-1) connects to the large circuit area that goes all the way up and around the rotary house code switch.

The other one (AC-2) is placed in one of five holes in a vertical line that joins a capacitor, a resistor, and a little wire.

Actually the little wire is a fuse. The #1 and #2 wires can be seen connecting to the terminals at the bottom of the transformer (pins 6 and 7). The other three wires need some explanation.

The #3 wire connects to what I refer to as +9V which is found at the bottom end of a 3300-ohm resistor, as shown. The #5 wire (what I call -9V) goes into a pre-existing, unused hole below the metal can near the left about halfway up (see the photo). The placement of the remaining wire (#4) depends on which channel this is to be used for.

For channel 1 or 5, it connects to pin 18 of the large IC. For channels 2 or 6: pin 19; for channels 3 or 7: pin 20; and for channels 4 or 8:

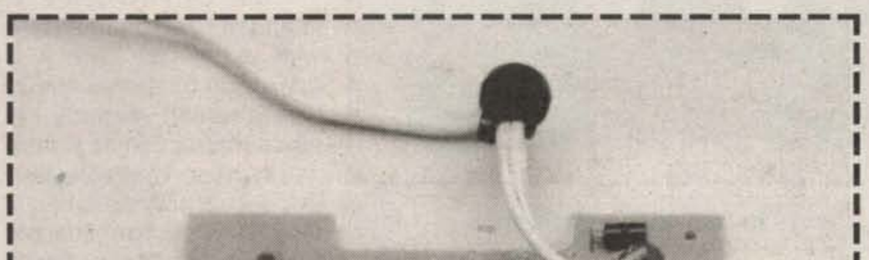

Photo 2. Top (component) side of the mini controller PC board.

Note that this fuse is between the power cord and our AC-2 wire. The fuse is thus protecting the mini controller circuitry and our THX10 circuit (for which the power drain is negligible).

A five-conductor wire is used to connect to the 12-volt output of the transformer T1 and three logic lines. pin 21. I made a small solder bead directly onto pin 18 of the IC and then tacked on the pre-tinned wire end with a low-power pencil-type soldering iron.

The five-conductor cable is then connected to a female connector to mate with the header on the THX10 board. Before connecting the two

boards together, first test the wired mini controller board by itself. For the first test, just plug in the AC line cord and make sure that nothing is smoking. Then, using a small meter set to AC, validate that wires #1 and #2 of the five-conductor cable are supplying 12-volt AC. Assuming all is well so far, unplug the unit, and connect a meter set to a 20-volt or higher DC scale to wires #3 and #5. Then, without touching anything, plug in the AC cord. You should see about 16 to 18 volts across these two wires on your meter. Then unplug the AC cord.

Assuming everything is wired up correctly, make sure the AC cord is unplugged, and connect the two PC boards, making sure wire #1 (the 12-volt AC) goes onto pin 1 of J1. Then plug in the AC cord. The THX10 board will then be powered via the 12-volt AC supply. After a few seconds, the three-blink self-test should appear on the THX10 LED. After a few more seconds, the LED on the mini controller should start to blink. You should see eight blinks. These are the eight bits that make up the temperature measurement. When the mini controller LED is finished, the LED on the THX10 board should start to blink, this time counting out the temperature in degrees F. If all goes well, then, the circuits are working fine together. Unplug the AC line cord and prepare the enclosure.

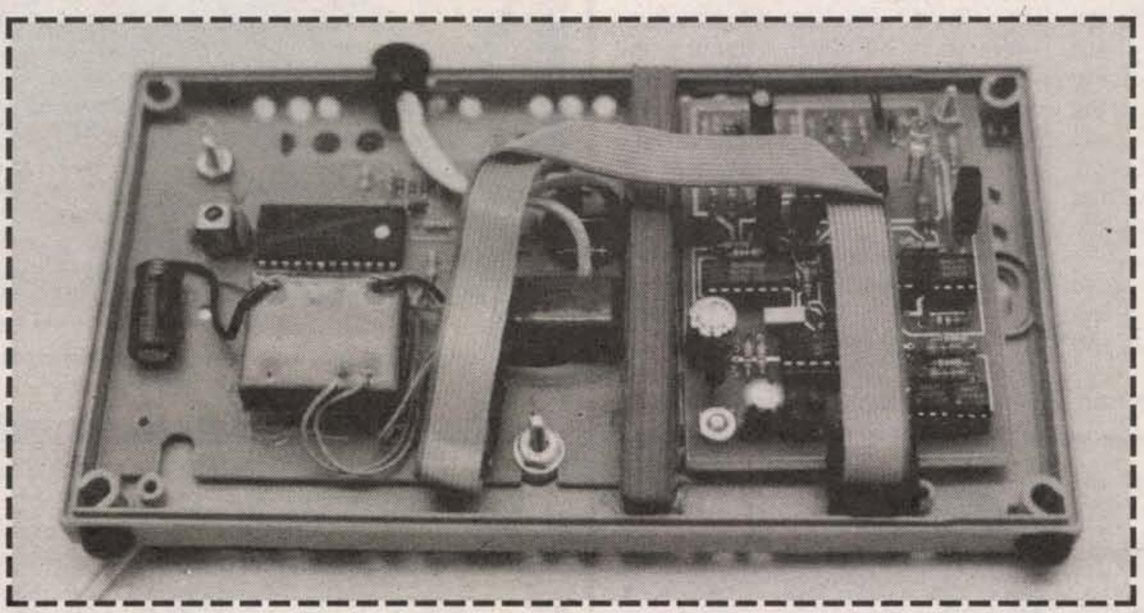

Photo 3. Mini controller and THX10 PC boards in half of the enclosure.

I used a small plastic case for the boards. In retrospect, I probably should have used one slightly larger, but the 4.5 x 8 x 1.25 size is now working fine.

The biggest problem of putting both boards into one case is that the mini controller PC board generates heat, enough heat to affect the sensors of the THX10 board. Therefore, you must thermally insulate two compartments in the same case, and vent each side separately.

Photo 3 shows the two boards in one half of the enclosure. Note the rubberized weather stripping between them; there is also weather stripping cemented in the same line on the other half of the enclosure. This keeps the heat on the mini controller side.

A large number of holes must be drilled on both ends. I oriented the case so the boards extend vertically, meaning the thin 1.25 inch side of the case is the base. A number of holes were drilled along both the bottom and the top sides to produce a 'chimney' effect that draws the heated air upward past the boards in each compartment.

This venting plus the thermal barrier (weather-stripping) is sufficient to isolate the two compartments thermally. Also drill a few holes in very close proximity to the two sensors.

Note that even though the two compartments of the case are thermally separate, the THX10 PC board is oriented so that the sensors are as far away from the mini controller board as possible.

For the front side of the case, drill a hole for LED1 while you are drilling all the vent holes. The PC boards are mounted to the back side using small screws and nuts. Use a grommet for a hole along the junction of the two halves to pass the line cord out of the case. Screw the two case halves together, and you're done. There is no on/off switch.

When you don't want it on, just unplug it. The mini controller is designed to run constantly, as is the THX10. If power should go out, when it comes back on, the THX10 will merely go through the self-test, then start to transmit.

The X10 Receiver

To receive the X10 codes from the remotes scattered throughout the house, I use an interface known at the CM11A X10 ActiveHome Two-Way Universal Computer Interface. The interface comes with software on CD (CK11A) as part of X10's 'Home Automation System.' The CM11A is a small cube (about the size of a power cube) that plugs into a 117-volt wall socket. It has a convenience outlet on the front. X10's literature says you should plug your computer into this outlet; this is to ensure that both the CM11A and your PC are both connected to the same ground.

The CM11A comes with a small cable that has a nine-pin RS/232 plug that should be connected to the serial port on a PC. If you want to use it with a 25-pin serial socket, you'll have to get a nine-pin to 25-pin converter, available at most stores selling PC equipment.

Although not as easy to find as the mini controllers, you shouldn't have any trouble obtaining a CM11A. RadioShack has one bundled with a few X10 light switches as a home automation system. You can order the unit from several home automation catalogs (see parts list); it costs about $45.00.

The CM11A device is intended to communicate with and monitor other X10 devices on the power line. It has internal memory in which macros can be stored.

A macro works like this: It is set to activate when it receives a certain channel code on a certain house code; it will then output a sequence of codes to other X10 units so that one light switch can be used to set off a whole sequence of events.

The CM11A has battery backup so that it will remember the macros when the computer is off or even on power outages.

The software on the CD allows you to program the macros, monitor X10 devices, generate output signals, etc. For our purposes, there is no need to install the software (unless you're dying to see how it works), or to install batteries, since we won't be using macros.

On the CD that comes with the CM11A, you can find a program 'COMTEST.EXE' that you can run from DOS or Windows that can be used to debug X10 systems. It monitors all the X10 activity on the house's wiring and prints it to the screen. With it, you can verify that your THX10 is actually sending out the 'on' and 'off' commands and that they are being sent on the prop-

er house code and channel numbers.

Also on the CD, you can find an information file called PROTOCOL.DOC (in Word format), or PROTOCOL.TXT (in plain text). This document explains how you can write your own programs to use the CM11A. It is quite complex, but a few things are worth noting. First, the interface uses 4800 baud, pretty slow by today's standards. Second, it has a maximum buffer size of 10 bytes. Since every X10 signal consists of multiple bytes, and since the baud rate is slow, any software using the CM11A must be written to make data transmission from the CM11A to the PC very high priority. Failure to do so could result in some loss of data from subsequent X10 control signals.

The COMTEST program can be used to make sure everything is working, but more customized software is needed to take advantage of the THX10 remote sensors. A BASIC program was written to at least get you started.

THMONIT BASIC Monitoring Programs

The diskette supplied with the THX10 chip contains two BASIC programs that can be used to monitor the temperature and humidity from multiple transmitters. The programs are:

- THMONITG.BAS — This program will work with GWBASIC, supplied with DOS versions 2-5.
- THMONITQ.BAS — This program will work with QBASIC, supplied with newer versions of DOS and Windows 3.1

Either of these programs will work with Windows 95/98, by running either of the GWBASIC or QBASIC interpreters. If you are running Windows 95/98 and do not have either of these BASIC interpreters, you can copy the appropriate GWBASIC.EXE or QBASIC.EXE files from an older computer to your new computer.

Running the Programs

The BASIC program can be run from DOS or Windows 3.1 for testing and debugging, but this is not recommended for full-time monitoring. These older operating systems do not support multiprocessing, so

```
0 REM   THMONITG.BAS — WORKS WITH GWBASIC
1 REM     BASIC PROGRAM TO MONITOR TEMPERATURE AND HUMIDITY
2 REM     COMMUNICATES WITH X10 CM-11 INTERFACE AS RECEIVER FOR THX10
3 REM     COPYRIGHT 1998 M. KERYAN
4 REM     SET YOUR SERIAL PORT IN RS% — LINE 20
5 REM     SET YOUR HOUSE CODE IN H$, AND ORDER # IN TH — LINE 30
6 REM      USE THIS TABLE TO FIND ORDER FOR THE HOUSE CODES:
7 REM      CODE:  A B C D E F G H I J K L M N O P
8 REM     ORDER: 6 14 2 10 1 9 5 13 7 15 3 11 0 8 4 12
9 REM     USER ROUTINES CAN BE ADDED IN SUBROUTINES AT LINES 4000 AND 5000
10 CLEAR: KEY OFF
20 RS% = 1
30 H$ = "F": TH = 9
100 REM  VARIABLES:
110 REM   A$      TEMPORARY STRING
120 REM   AC(NA)  ACTIVE CHANNEL # FROM INTERFACE
122 REM   AH(7)   RUNNING AVG. HUMID. FOR EA. CHAN.
124 REM   AT(7)   RUNNING AVG. TEMP. FOR EA. CHAN.
130 REM   B       BIT, 0 OR 1
140 REM   BC      BITCODE, TEMP FOR NB%
150 REM   BD      BITDATA, TEMP
160 REM   BY%(7) BYTE FOR EA. CHAN., TEMP HOLDING
170 REM   C       CHAR FROM BUFFER
171 REM   CA%(255)  CHAR. BUFFER
172 REM   CB%     BEGINNING OF CHAR. BUFFER
173 REM   CE%     END OF CHAR. BUFFER
175 REM   CI      CHARACTER INPUT
176 REM   CM%     MAXIMUM BUFFER SIZE
180 REM   CN      CHAN. NO. RECEIVED
190 REM   D%      DEV. CODE OR COMMAND CODE
200 REM   DC      DEV. # (TRANSLATED)
210 REM   H$      HOUSE CODE STRING TO LOOK FOR
220 REM   H       HOUSE CODE RECEIVED
225 REM   HI      HEAT INDEX
230 REM   I       TEMP INDEX COUNTER
240 REM   IM      IS MASK, FLAG = 1 IF MASK, -1 IF NOT
250 REM   MA      MASK BYTE FROM INTERFACE
260 REM   NA      COUNTER OF ACTIVE CHANNEL
270 REM   N%(15)  X10 CODE ORDER
280 REM   NB%(7)  NUM.BIT FOR EA. CHAN.
285 REM   NE%(7)  NUMBER OF ERRORS FOR HR
290 REM   NO%(7)  NUMBER OF TIMEOUTS FOR HR
300 REM   NH%(7)  NUMBER OF HUMID. SAMPLES FOR HR
310 REM   NT%(7)  NUMBER OF TEMPER. SAMPLES FOR HR
320 REM   NC      NUMB. OF CHAR TO FOLLOW FROM INTERFACE
330 REM   OH$     OLD HOUR
340 REM   OM$     OLD MINUTE
350 REM   OS$     OLD SECOND
360 REM   RES$    RESPONSE STR
370 REM   RS$     SERIAL PORT  ("COM1" OR "COM2")
371 REM   RS%     SERIAL PORT  (1 OR 2)
380 REM   SM%(7)  START MINUTE (0-1439) FOR CHAN
385 REM   SN%(7)  STABLE NOW COUNTER FOR CHAN (STABLE IF > 10)
390 REM   SH(7)   SUM HUMIDITY FOR HR
400 REM   ST(7)   SUM TEMPERATURE FOR HR
410 REM   TH      THIS HOUSE # TO LOOK FOR
420 REM   TI$     TIME STRING
430 REM   TM      THIS MASK; MASK BIT FOR A BYTE, 0 OR 1
432 REM   UH%(7)  UNSTABLE COUNTER FOR EA. CHAN
434 REM   UT%(7)  UNSTABLE COUNTER FOR EA. CHAN
440 REM   X%      TEMPORARY X
450 REM   Y%      TEMPORARY Y
460 REM   Z%      TEMPORARY Z
470 REM   Z$      ZERO CHAR
900 REM
1000 REM START OF PROGRAM
1010 CLS : FOR I = 1 TO 25: PRINT : NEXT I
1020 GOSUB 1100
1030 ON COM(RS%) GOSUB 3000
1040 COM(RS%) ON
1060 IF (CE% = CB%) THEN 1080
1070 GOSUB 3100: GOSUB 2000
1080 GOSUB 1200
1090 GOTO 1060
1100 Z$ = CHR$(&H0): RES$ = CHR$(&H9B) + STRING$(6, Z$)
1105 RS$ = "COM" + RIGHT$(STR$(RS%), 1)
1110 RS$ = RS$ + ":4800,N,8,1,RS,CS0,DS0,CD0": OPEN RS$ FOR RANDOM AS #2
1130 DATA 12,4,2,10,14,6,0,8,13,5,3,11,15,7,1,9
1140 DIM N%(15): FOR I = 0 TO 15: READ N%(I): NEXT I
1150 DIM NB%(7), BY%(7), SM%(7): FOR I = 0 TO 7: SM%(I) = -1: NEXT I
1160 DIM SH(7), ST(7), NO%(7), NE%(7), NH%(7), NT%(7), CA%(255)
1165 DIM AH(7), AT(7), SN%(7), UH%(7), UT%(7)
1170 A$ = TIME$
1175 IF (A$ = TIME$) GOTO 1175
1180 A$ = "TH" + RIGHT$(DATE$, 2) + LEFT$(DATE$, 2) + MID$(DATE$, 4, 2) + ".LOG"
1185 OPEN A$ FOR OUTPUT AS #3: PRINT #3, "LOG for "; DATE$; " started "; TIME$;
1190 PRINT #3, " X-10 House Code "; H$
1199 RETURN
1200 TI$ = TIME$
1210 IF (LEFT$(TI$, 2) <> OH$) THEN GOSUB 1300: OH$ = LEFT$(TI$, 2)
1220 IF (MID$(TI$, 4, 2) <> OM$) THEN GOSUB 1400: OM$ = MID$(TI$, 4, 2)
1230 IF (RIGHT$(TI$, 2) <> OS$) THEN GOSUB 1500: OS$ = RIGHT$(TI$, 2)
1240 RETURN
1300 IF (OH$ = "") THEN RETURN
1310 PRINT #3, "": PRINT #3, "Averages for Hour "; OH$
1320 FOR I = 0 TO 7: IF ((NO%(I) + NE%(I) + NH%(I) + NT%(I)) = 0) GOTO 1370
1330 X% = 0: IF (NH%(I) > 0) THEN X% = CINT(SH(I) / NH%(I))
1340 Y% = 0: IF (NT%(I) > 0) THEN Y% = CINT(ST(I) / NT%(I))
1350 PRINT #3, USING "Ch. # "; (I + 1);
1352 PRINT #3, USING "### deg F "; Y%; : PRINT #3, USING "(#)  "; NT%(I);
1354 PRINT #3, USING "### % RH "; X%; : PRINT #3, USING "(#)  "; NH%(I);
1360 PRINT #3, USING "## Time-outs"; NO%(I);
1365 PRINT #3, USING " ## Bad data"; NE%(I);
1367 GOSUB 3500: PRINT #3, USING "  Heat Index: ###"; HI
```

while the monitor program is running, your PC cannot do anything else. One thing that you may want to do concurrently is to review older log files.

If you are running the monitor program in a DOS window in Windows 3.1, you can click on another window to review or print the log files, but in doing so, the monitor program will be temporarily off-line. Doing the same thing in a Windows 95/98 window will allow the monitor program to continue to run at the same time that you are inspecting log files, printing, etc.

Using QBASIC

Use the 'Start,' 'Run ...' menus. Either type in the pathname and filename (such as C:\DOS\QBASIC.EXE) and 'Open,' or find the file by the 'Browse' menu and then open it. You will see an opening screen; press the escape key, then use the menus ('File,' 'Open') to load the basic program 'THMONITQ.BAS.' Then use the menus ('Run' then 'Start') to run the program. After a few seconds, you will see the time of day at the bottom of the screen, indicating that it is running.

Using GWBASIC

Use the 'Start,' 'Run ...' menus. Either type in the pathname and filename (such as C:\DOS\GWBASIC.EXE) and 'Open,' or find the file by the 'Browse' menu and then open it. You will see an 'OK' printed out. Type the sequence: LOAD "xxxxTHMONITG.BAS," where xxxx is filled in with the path to the program, such as C:\DOS\ or A:\, or wherever you have placed the THMONITG.BAS file. To confirm that it loaded, type LIST, and you should see the program listing scroll past. To run it, type RUN.

To toggle back and forth from a full-size screen to a window on the desktop, press 'Alt-Enter' (both keys at once). If you want to quit the program, press 'Ctrl-Break' (two keys at once). To exit GWBASIC, type SYSTEM. To exit QBASIC, use the menus.

Customizations

The programs are set up for serial port 1 (COM1), and for monitoring X10 house code 'F.' If either of these need to be changed, you should update the statements in lines 20 and 30 of the program for your serial port or house code.

Description of Monitoring Program

The monitor program talks to a CM11A interface through the serial port of your PC. The CM11A monitors all X10 communications on your house's power line. The program decodes the information coming from the CM11A and sends back appropriate handshaking information. The monitor program determines if the X10 information corresponds to the specific house code that you are monitoring (default is house code 'F'). If so, it saves the information in a buffer for each allowable channel (1 through 8), and when enough information is attained, it takes appropriate action.

The temperature/humidity transmitter sends the data as a series of eight 'on' or 'off' X10 sequences to build up a byte (eight bits). When the eighth bit is received, the program figures out if it is a temperature (binary value of 0-127) or humidity (128-255). For the humidity data, the eighth bit is stripped off. The data is printed on the screen immediately after it is received. The value is compared to a running average for that channel; if it is more than 15 units from the average, it is assumed to be garbled and it is discarded. Good data is retained and later printed out as part of the hourly average in the log file created for that day.

The temperature/humidity transmitters send one set of data every five to six minutes, alternating between temperature and humidity. Typically, each channel will then send about five to six temperatures and five to six humidities every hour. If all eight channels are active, this means over 80 sets of data every hour. The more active channels, the higher the chance for data collisions. When more than one transmitter is sending data at exactly the same instant, there is a good chance that one of them will be ignored by the CM11A receiver. When this happens, the full eight bits for the sample will never be received. To handle this, the program uses timeouts.

A timeout will occur if more than one but less than eight bits are received within a three-minute period for any specific channel. A timeout means the data is incomplete and it is discarded; it resets the bit counters for that channel so the next series (five to six minutes later) can be received. Timeouts will occur due to data collisions using more than one channel. Since environmental monitoring is not a mission-critical application, and actual temperature and humidity changes usually take 20-30 minutes, a loss of a few samples is not a problem.

A new log file is created on disk for each day that the monitor program is running. The date is encoded in the file name (for example 'TH981215.LOG' is the file created for December 15, 1998). The file is written out at midnight and a file for the new day is then opened. The log file lists one line of information for every active channel every hour (0-23).

An active channel is any channel on the house code for which there was any activity: temperature, humidity, timeouts, or errors. The average for the hour is printed out with the number of samples in parenthesis for both temperature and humidity. The number of timeouts and errors is also printed out. The last thing on each line is the heat index calculation for the average temperature and humidity.

While the program is running, the time of day is continually updated at the bottom of the screen. When any transmitter for the moni-

```
1370 NEXT I: FOR I = 0 TO 7: NO%(I) = 0: NE%(I) = 0: NH%(I) = 0: NT%(I) = 0
1380 SH(I) = 0: ST(I) = 0: NEXT I
1385 IF (OH$ = "23") THEN PRINT #3, "Maximum character buffer:"; CM%
1390 IF (((OH$ = "24") OR (OH$ = "23")) AND (LEFT$(TI$, 2) = "00")) GOTO 10
1399 RETURN
1400 FOR I = 0 TO 7: IF (SM%(I) < 0) GOTO 1450
1410 X% = VAL(OM$) + 60 * VAL(OH$)
1420 IF ((X% - SM%(I)) < 3) GOTO 1450
1430 CN = I: PRINT "Ch."; (CN + 1); "  Time-out   "; TI$: GOSUB 2900
1440 NO%(CN) = NO%(CN) + 1
1450 NEXT I: GOSUB 1650
1460 IF (RIGHT$(OM$, 1) = "2") THEN I = FRE(A$)
1490 RETURN
1500 Y% = CSRLIN: X% = POS(0): LOCATE 25, 20: PRINT TI$; : LOCATE Y%, X%
1510 IF (RIGHT$(OS$, 1) = "2") THEN A$ = "          ": Z% = 50: CN = 0: GOSUB 1680
1590 RETURN
1600 A$ = CHR$(CN + 49): Z% = 0: GOTO 1680
1610 A$ = " ": Z% = 0: GOTO 1680
1620 I = N%(CN)
1630 CN = I: A$ = CHR$(CN + 65): Z% = 30: GOTO 1680
1650 A$ = "          ": CN = 0: Z% = 30: GOTO 1680
1680 Y% = CSRLIN: X% = POS(0): LOCATE 25, FIX(CN + Z% + 1): PRINT A$;
1690 LOCATE Y%, X%: RETURN
2000 REM
2010 IF (NC > 0) THEN NC = NC - 1: GOTO 2100
2020 IF (C = 90) THEN PRINT #2, CHR$(&HC3); : RETURN
2030 IF (C = 165) THEN PRINT #2, RES$; : RETURN
2040 IF (C = 0) THEN PRINT #2, Z$; : RETURN
2050 IF (C = 85) THEN RETURN
2060 IF (C > 9) THEN PRINT "ERR " + HEX$(C): RETURN
2070 NC = C: IM = -1: RETURN
2100 IF IM < 0 THEN MA = C * 2: IM = 1: RETURN
2110 MA = MA / 2: TM = INT(MA) AND 1
2120 H = INT(C) AND 240: H = H / 16: D% = INT(C) AND 15
2130 CN = H: GOSUB 1620: IF (H <> TH) THEN RETURN
2140 IF (TM = 1) GOTO 2200
2150 DC = N%(D%)
2170 IF (DC = 999) THEN RETURN
2180 AC(NA) = DC: NA = NA + 1: RETURN
2200 IF ((D% < 2) OR (D% > 3)) THEN NA = 0: RETURN
2210 B = 1: IF (D% = 3) THEN B = 0
2220 FOR I = 0 TO (NA - 1): CN = AC(I): BC = NB%(CN)
2230 IF (BC = 0) THEN BC = 1: BD = 1 AND INT(B): SM%(CN) = VAL(OM$) + 60 * VAL(OH$):
GOSUB 1600: GOTO 2250
2240 BC = BC * 2: BD = INT(BC) * INT(B)
2250 BY%(CN) = BY%(CN) + INT(BD): NB%(CN) = INT(BC)
2260 IF (BC > 127) THEN GOSUB 2500
2270 NEXT I: NA = 0: RETURN
2500 Z% = BY%(CN) AND 127
2510 PRINT "Ch."; (CN + 1); RIGHT$("    " + STR$(Z%), 4);
2520 SN%(CN) = SN%(CN) + 1
2530 IF (BY%(CN) > 127) GOTO 2700
2600 PRINT " Deg F   "; TI$;
2610 IF (SN%(CN) < 10) GOTO 2650
2620 IF (ABS(Z% - AT(CN)) < 16) GOTO 2640
2630 PRINT "   ERROR ASSUMED"; : NE%(CN) = NE%(CN) + 1: GOTO 2800
2640 AT(CN) = (4 * AT(CN) + Z%) / 5: GOTO 2670
2650 AT(CN) = UT%(CN) * AT(CN) + Z%
2660 UT%(CN) = UT%(CN) + 1: AT(CN) = AT(CN) / UT%(CN)
2670 ST(CN) = ST(CN) + Z%: NT%(CN) = NT%(CN) + 1
2672 IF (UH%(CN) = 0) GOTO 2680
2675 Y% = Z%: X% = AH(CN): GOSUB 3500: PRINT USING "   Heat Index: ###"; HI;
2680 GOSUB 4000: GOTO 2800
2700 PRINT " % RH    "; TI$;
2710 IF (SN%(CN) < 10) GOTO 2750
2720 IF (ABS(Z% - AH(CN)) < 16) GOTO 2740
2730 PRINT "   ERROR ASSUMED"; : NE%(CN) = NE%(CN) + 1: GOTO 2800
2740 AH(CN) = (4 * AH(CN) + Z%) / 5: GOTO 2770
2750 AH(CN) = UH%(CN) * AH(CN) + Z%
2760 UH%(CN) = UH%(CN) + 1: AH(CN) = AH(CN) / UH%(CN)
2770 SH(CN) = SH(CN) + Z%: NH%(CN) = NH%(CN) + 1
2772 IF (UT%(CN) = 0) GOTO 2780
2775 X% = Z%: Y% = AT(CN): GOSUB 3500: PRINT USING "   Heat Index: ###"; HI;
2780 GOSUB 5000
2800 PRINT " "
2899 REM USE THIS TO DEBUG   PRINT #3, BY%(CN); "="; Z%; "  ";
2900 NB%(CN) = 0: BY%(CN) = 0: SM%(CN) = -1: GOSUB 1610: RETURN
3000 IF (EOF(2)) THEN RETURN
3010 CI = ASC(INPUT$(1, #2))
3020 CE% = CE% + 1: IF (CE% > 255) THEN CE% = CE% - 256
3030 CA%(CE%) = CI: GOTO 3000
3100 CB% = CB% + 1: IF (CB% > 255) THEN CB% = CB% - 256
3110 C = CA%(CB%)
3120 X% = CE% - CB% + 1: IF (X% < 0) THEN X% = X% + 256
3130 IF (X% > CM%) THEN CM% = X%
3140 CN = 0: Z% = 50: A$ = "Buf: " + STR$(X%) + "  ": GOSUB 1680
3150 RETURN
3500 HI = -42.379 + 2.04901523# * Y% + 10.1433127# * X% - .22475541# * Y% * X%
3510 HI = HI - 6.83783 * 10 ^ -3 * Y% * Y% - 5.481717 * 10 ^ -2 * X% * X%
3520 HI = HI + 1.22874 * 10 ^ -3 * Y% * Y% * X%
3530 HI = HI + 8.5282 * 10 ^ -4 * Y% * X% * X%
3540 HI = HI - 1.99 * 10 ^ -6 * Y% * Y% * X% * X%
3550 RETURN
4000 REM ADD YOUR ROUTINE HERE FOR ACTION ON TEMPERATURE
4010 REM TEMPERATURE IS IN VARIABLE Z%
4990 RETURN
5000 REM ADD YOUR ROUTINE HERE FOR ACTION ON HUMIDITY
5010 REM HUMIDITY IS IN VARIABLE Z%
5990 RETURN
```

tored house code is received, the channel number will appear at the bottom left side of the screen. The channel number will remain on the screen until either the full eight bits are received, or there is a timeout.

When the full eight bits are received, one line of information is scrolled onto the screen showing the channel number, the type and the data (temperature or humidity), and the time received. The program will also monitor other house codes and display the house code received at the bottom right of the screen for a few seconds.

Enhancements to the Software

The monitor program currently does the bare minimum. It keeps track of data from the CM11A, it decodes it, it fills matrices for temperatures and humidities, and it prints averages to log files on disk. It probably doesn't do everything YOU want it to do.

For example, you may want to send data to a printer, take action if the temperature or humidity falls outside of a predetermined range, etc. You might want to send commands to the CM11A to transmit data, for example, on a different house code that is monitored by another CM11A connected to a PC and a heating/air-conditioning system.

Stub subroutines are jumped to when valid data is received; you can add your routines there. Feel free to change the program, port it to Visual Basic, port it to C, C++, or Java, or port it to Linux. Send any major modifications to me via E-Mail: mkeryan@pobox.com.

Using the THX10 System

The best locations for the THX10 remote units are:

- Three to four feet above the floor. It is always cooler near the floor and warmer near the ceiling. The sensors should be at about the same height as the bulk of your body.
- Away from registers or drafts that would give false readings. This assumes you don't want to monitor the temperature from the air conditioner. Of course, you might want to, for example to ensure that it is working. In that case, you can place a THX10 unit directly on top or in front of the register outlet.
- Away from heat-generating equipment. For example, don't place it on top of a TV, computer monitor, or refrigerator.
- Generally, the best places are on top of counters, desks, tables, etc. Make sure it is not in direct contact with anything on any of its four sides, to ensure adequate ventilation.
- Place them in the rooms you would like monitored: master bedroom, kid's room, kitchen, family room, etc. You don't have to place it in the hallway like your thermostat. You can monitor the actual living conditions in the rooms you actually live in.
- If you want to determine how hard your HVAC system is working, you can dedicate one or two units to monitor the outside environment, such as in an unheated/uncooled attic, and on a screened porch. However, make sure that environment is clean and there is no chance that the unit could come in contact with water. Direct sunlight should also be avoided.

Even though X10 systems are described as 'Whole-House' systems, don't be surprised if units placed in some rooms cannot be received on your CM11A/PC receiving system. Most homes have a 220-volt power system that is split into two 110-volt legs at the breaker box. Therefore, some outlets are wired on leg-1, while others are connected to leg-2.

If your CM11A/PC happens to be on leg-1, the THX10 transmissions on leg-2 may not be picked up. If you have this problem, you may be able to move the THX10 unit to another wall (some rooms may be wired using both legs on opposite walls), or to another room close to the room you want monitored.

In those cases in which moving them around just doesn't work, then a signal bridge will solve the problem. This is a small device, costing about $40.00, that is installed in the breaker box. It passes X10 signals from one leg over to the other leg.

There are also X10 signal amplifiers that boost the signals; these may be needed in very large houses. You can find these devices in home automation catalogs.

You may find that after a power outage, you get a lot of timeouts and/or bad data for a while. This is because all the THX10 units came up at the same moment when the power came back on and are in sync; they are all trying to send data at exactly the same time. This causes data collisions, and a loss of data.

After a while, they will get out of sync all by themselves because the resonators clocking the PIC CPUs are not very precise. You can speed up this process to randomize the sequencing by unplugging and then plugging back in several of the units, one at a time, at one-minute intervals.

Occasionally, even without a power failure, this synchronization will occur between two or more units, and you will lose some data until they fall out of sync. The system is based on redundancy; your monitoring software should make decisions based on a consensus of results, not just on one particular sensor. That way, if data from any one sensor is lost, the whole system continues to operate. **NV**

HOW TO PLACE A CLASSIFIED AD

TYPE or PRINT your **ELECTRONICALLY RELATED** ad copy **CLEARLY (not all caps)** on a separate piece of paper. Spell out words when submitting handwritten copy. Calculate the number of words and multiply it by the appropriate rate (see RATE PER WORD section). Include any charges for **bold** and/or CAPPED words, any artwork costs that would be applicable, and/or costs for boxing your ad (explained below). Choose the appropriate classification for your ad(s) to appear in (see below). If no classification is indicated, it will be placed in Misc. Electronics or wherever we deem most suitable. **Enclose your name, address, phone number, and *Nuts & Volts* account number from your mailing label** (if available) for identification purposes. Include full payment — **CLASSIFIEDS RUN ON A PRE-PAID BASIS ONLY** — and mail your completed order to:

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You may fax in ad copy or changes before the closing date (5:00pm on the **5th**) at 909-371-3052 using MasterCard or Visa. Include credit card expiration date, the name that appears on the card, a daytime phone number, and your *Nuts & Volts* account number. Ads without credit card information will not be listed as received until payment is received in full. **WE DO NOT CALL OR FAX BACK VERIFICATION OR QUOTES OF FAXED-IN ADS.** For verification of faxed-in ads, please call 909-371-8497.

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Prepaid ads received by 5:00pm on the **closing date (5th of the month)** will appear in the following month's issue. Ads postmarked through the **5th**, but received after the closing date, will be placed in the next available issue. No cancellations or changes after the 5th. Cancellations and changes must be submitted in writing.

IMPORTANT INFORMATION

All classified ads are running copy only. No special positioning, centering, dot leaders, extra space, etc. is allowed. All advertising in *Nuts & Volts* is limited to **electronically related items ONLY**. All ads are subject to approval by the publisher. We reserve the right to reject or edit any ad submitted. We do not take ad copy or changes over the phone. We do not bill for classified ads. Repeat ads or ads run in multiple classifications within the same issue are allowed. Paid subscribers may run ads at the 60¢ rate only through their subscription expiration date. **NO REFUNDS**. Credit only. No credit for typesetting errors will be issued unless you *clearly* print or type your ad copy.

Choose a category for your ad from the classifications listed below.

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Tucson 85713
The Electronic Thrift Store
12329 N.W. Grand Ave. #F
El Mirage 85375
Tower Records
3 E. 9th St.
Tempe 85281

AUSTRALIA
DonTronics
P.O. Box 595
29 Ellesmere Cres.
Tullamarine 3043
www.dontronics.com

CALIFORNIA
Abletronics
9155 Archibald Ave. Unit E
Cucamonga 91730
Advanced Computer Products, Inc.
1310 "B" E. Edinger Ave.
Santa Ana 92705
All Electronics
905 S. Vermont Ave.
Los Angeles 90006

14928 Oxnard St.
Van Nuys 91411
Allen's To Go
13461 Hwy. 88
Lockeford 95237
Alltronics
2300-D Zanker Rd.
San Jose 95131
Brand Newsstand
234-1/2 N. Brand Blvd.
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Centerfold International
716 N. Fairfax Ave.
Los Angeles 90046
Del Amo Books & News
3758 Sepulveda Blvd.
Torrance 90505
DSS Satellite Comm.
411-E 18th St. #C
Oakland 94606
Electro Mavin
2985 E. Harcourt St.
Rancho Dominguez 90221
Ford Electronics
8431 Commonwealth Ave.
Buena Park 90621
Harding Way News
113 W. Harding Way
Stockton 95204
Harold's Newsstand
524 Geary St.
San Francisco 94102
HdB Electronics
2860 Spring St.
Redwood City 94063
Hi-Fi Doctor
1814 E. Ball Rd.
Anaheim 92805
HSC Electronic Supply
4837 Amber Ln.
Sacramento 95841

3500 Ryder St.
Santa Clara 95051

5681 Redwood Dr.
Rohnert Park 94928
Hyatt Electronic Surplus
371 N. Johnson Ave.
El Cajon 92020
JK Electronics
6395 Westminster Ave.
Westminster 92683
Laurel Park News
4346 Laurel Canyon Blvd.
Studio City 91604
Lion Electronic Labs
4948 E. Townsend Ave.
Fresno 93727
Netseller
7207 Arlington Ave. Ste. G
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Op Amp Technical Books
1033 N. Sycamore Ave.
Los Angeles 90038
Panorama Electronics
8737 Van Nuys Blvd.
Panorama City 91402
Sandy's Electronics Supply, Inc.
20655 Soledad Cyn. Rd. #15
Santa Clarita 91351
Sav-On Electronics
13225 Harbor Blvd.
Garden Grove 92643
SIERRA MADRE NEWSSTAND
55 N. Baldwin Ave.
Sierra Madre 91024
The Red Barn
Hwy. 299
Bieber 96009
Tower Books
211 Main St.
Chico 95928

7840 Macy Plaza Dr.
Citrus Heights 95610

1280 E. Willow Pass Rd.
Concord 94520

630 San Antonio Rd.
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1600 Broadway
Sacramento 95818

5950 Florin Rd.
Sacramento 95823

2538 Watt Ave.
Sacramento 95812

2727 El Camino Real
San Mateo 94403
Tower Magazines/News
885 Riverside Pkwy.
West Sacramento 95605
Tower Records/Video
220 N. Beach Blvd.
Anaheim 92801

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5703 Christie Ave.
Emeryville 94608

2052 Redwood Hwy.
Greenbrae 94904

6310 E. Pacific Coast Hwy.
Long Beach 90803

2280 Market St.
San Francisco 94114

3205 20th Ave.
San Francisco 94132

2525 Jones St.
San Francisco 94133

871 Blossom Hill Rd.
San Jose 95123

1205 W. Covina Pkwy.
West Covina 91790
Video Electronics
3829 University Ave.
San Diego 92105

CANADA
Com-West Radio Systems Ltd.
48 E. 69th Ave.
Vancouver, BC V5X 4K6
Muir Communications Ltd.
3214 Douglas St.
Victoria, BC V8Z 3K6

COLORADO
TH Electronics
216 Commerce Dr., Unit 2
Ft. Collins 80524
Tower Records/Video
2500 E. 1st Ave.
Denver 80206
Western Test Systems
530 Compton #C
Broomfield 80020

CONNECTICUT
Archway News
64 Bank St.
New Milford 06776
Electronic Service Products
437 Washington Ave.
North Haven 06473

DELAWARE
Newark Newsstand
70 E. Main St.
Newark 19711

DISTRICT OF COLUMBIA
Tower Records
2000 Pennsylvania Ave.
Washington 20006

FLORIDA
Alfa Electronic Supply
1502 S. St. Rd. #7
Hollywood 33023
Al's News
8219 S.W. 124th St.
Miami 33156
Bob's News & Books
1515 S. Andrew Ave.
Fort Lauderdale 33316
Clarks Out of Town News
303 S. Andrews Ave.
Fort Lauderdale 33301
Mike's Electronic Distributing Co.
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Fort Lauderdale 33309
Skycraft Parts & Surplus, Inc.
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Winter Park 32789
Sunny's At Sunset, Inc.
8260 Sunset Strip
Sunrise 33322

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Tower Records
3400 Around Lenox Dr.
Atlanta 30326

HAWAII
SolarWorks!
525 Lotus Blossom Ln.
Ocean View 96737
Tower Records
4211 Waialae Ave.
Honolulu 96816

611 Keeaumoku
Honolulu 96814

IDAHO
The Current Source
5159 Glenwood
Boise 83714

ILLINOIS
City Newsstand
4018 N. Cicero
Chicago 60641
Tower Records/Video/Books
383 W. Army Trail Rd.
Bloomingdale 60108

2301 N. Clark St. #200
Chicago 60614

1209 E. Golf Rd.
Schaumburg 60173

INDIANA
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108 Park 32 W. Dr.
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Hollywood At Home
9063 Metcalf Ave.
Overland Park 66212
Lloyd's Radio & Electronic, Inc.
220 W. Harry St.
Wichita 67213

LOUISIANA
Lakeside News
3323 Severn Ave.
Metairie 70002

MARYLAND
Silicon Valley Electronics
2014-A Industrial Dr.
Annapolis 21401
Tower Records/Video
2566 Solomons Island Rd.
Annapolis 21401

1601 Rockville Pike #210
Rockville 20852

MASSACHUSETTS
Full Spectrum Communications
244 Essex St.
Salem 01970
Newsbreak, Inc.
579 G.A.R. Hwy. Rt. 6
Swansea 02777
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360 Newbury St.
Boston 02115

MICHIGAN
Little Professors Book Center
22174 Michigan Ave.
Dearborn 48124
MW Electronics
229 E. Michigan Ave.
Paw Paw 49079
Purchase Radio Supply, Inc.
327 E. Hoover Ave.
Ann Arbor 48104
Tower Records
1214 S. University Ave.
Ann Arbor 48104

MINNESOTA
Radio City, Inc.
2633 County Road 1
Mounds View 55112

MISSOURI
Accurate Instruments
11201 E. 24 Hwy.
Independence 64054
Electronics Exchange
8644 St. Charles Rock Rd.
St. Louis 63114

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Amateur Electronic Supply
1072 N. Rancho Dr.
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VSTG-22
North Las Vegas 89030
Radio World
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Boulder City 89005
Tower Records/Video
4580 W. Sahara Ave.
Las Vegas 89102

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Sys-Com
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2112 Central S.E.
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Brentwood 11717
Goldcrest Electronics
480 St. Paul St.
Rochester 14605
Ham Central
3 Neptune Rd.
Poughkeepsie 12601
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219 California Dr.
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7603 Mentor Ave.
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News & Smokes #8
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Medford 97501
Norvac Electronics
7940 S.W. Nimbus Ave. Bldg. 8
Beaverton 97005

960 Conger
Eugene 97402

1545 N. Commercial N.E.
Salem 97303
Powell's Technical Bookstore
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Portland 97209
Taylor News & Books
133 W. Main, Ste. 102
Oklahoma City 73102
Tower Books
1307 N.E. 102nd Ave.
Portland 97220

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308 Bedford St.
Johnstown 15901
Genes Books, Inc.
King of Prussia Plaza
King of Prussia 19406
Lehman Scientific
2997-F Cape Horn Rd.
Red Lion 17356
Montco Electronics & Computers
2555 Industry Ln. Ste. D
Norristown 19403
Surplus Al
RR 1 Box 337
Hunlock Creek 18621
Tower Books
425 South St.
Philadelphia 19147
Tower Records
340 W. Dekalb Pike
King of Prussia 19406

SOUTH CAROLINA
555 Electronics
5646 Farrow Rd.
Columbia 29203

TENNESSEE
Tower Books
204 W. End Ave.
Nashville 37203

TEXAS
BDL News, Inc.
809 Pierce
Houston 77002
Electronic Parts Outlet
3753-B Fondren Rd.
Houston 77063
Mouser Electronics
958 N. Main St.
Mansfield 76063
Tanner Electronics
1301 W. Beltline #105
Carrollton 75006
Tower Records
2403 Guadalupe
Austin 78705

VIRGINIA
Satellite Headquarters
7920 Timberlake Rd.
Lynchburg 24502
Tower Records/Video/Books
4110 W. Ox Rd. #12124
Fairfax 22033

1601 Willow Lawn Dr.
Richmond 23230

8389 E. Leesburg Pike
Vienna 22182

WASHINGTON
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Service Request
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Supertronix
18650 68th Ave. S.
Kent 98032
Tower Books
10635 N.E. 8th St.
Bellevue 98004

20 Mercer St.
Seattle 98109

WISCONSIN
Amateur Electronic Supply, Inc.
5710 W. Good Hope Rd.
Milwaukee 53223
Greenfield News & Hobby
6815 W. Layton Ave.
Greenfield 53220
Cudahy News & Hobby Ctr.
4758 Packard Ave.
Cudahy 53110

Don Lancaster's

RESOURCE BIN

number eighty six

Supraluminal dowsing for Brown's Gas in Roswell.

Our usual reminder here that the *Resource Bin* is a two-way column. You can get tech help, consultant referrals, and off-the-wall networking on nearly any electronic, *tinaja questing*, personal publishing, money machine, or computer topic by calling me at **(520) 428-4073** weekdays 8-5 Mountain Standard Time.

Be certain to frequently check out my new *Guru's Lair* website you'll find at (where else?) www.tinaja.com. This is the place you'll go for instant tech answers. Among the many files in our library, you will find complete reprint sets for all of the *Resource Bin* and other columns. Plus a brand new Research InfoPack Service.

Exploring the Pseudoscience Morass

When you want to supraluminally dowse for Brown's Gas in Roswell, the proper way to do so would be by using an overunity water-fueled black helicopter.

I have long been fascinated by all *pseudoscience* topics. Stuff which the Houyhnhnms politely termed "that which is not so." Extraordinary claims for which any extraordinary evidence does not and can not exist.

The usual cause for the mountains of dead wrong urban lore is *labwork so mesmerizingly awful that it is not even wrong*. Accurately measuring any AC power or small temperature changes are both exceptionally difficult tasks. And it is super easy to forget that an hour in the library is worth a month in the lab. Or that physics and thermo "laws" are really *theorems*. Which, in turn, are those *unavoidable consequences* of the fundamental first principles. Or that real science and real engineering *always* gets done by standing on the shoulders of giants.

Should you ever find any unusual result, scientific integrity *demands* you make monumental efforts which *prove yourself wrong*. And that you openly and aggressively welcome a criticism and critique. You are *always* guilty till proven correct. And, no, it is not up to others to prove you are wrong. It is *always* up to you to convince others that you are right.

One of the big dangers of wishing for something is that you may get it. I strongly feel that finding a source of unlimited free energy would be one of the most heinous possible crimes against humanity. One which would make Hitler look like Mother Teresa.

For the out-of-control binge which would certainly result would quickly turn the planet into a cinder. Global warming would then get measured in degrees per hour, rather than degrees per century.

NEXT TIME: Don takes another look at test equipment options.

At any rate, I thought we might take a pseudoscience tour ...

Art Bell

Well, the 800-pound pseudoscience gorilla, of course, is the Art Bell show. Late night talk radio for insomniacs who tire of listening to crickets. His subject matter ranges through UFOs, Nevada's Area 51 (the source of the show), catastrophic predictions, the happy faces on Mars, crop circles, free energy claims, even that entire space program being nothing but a staged Truman-like TV show.

One recent caller provided his eye witness web photos of an alien that he shot and then stuffed into his freezer. Before, of course, those "men in black" stole the freezer. It wasn't very long before discovery of the clip art from where his compact black oblisk space ship was gotten.

Naturally, all Art's regular listeners were quick to question just what the aliens were doing with their clip art collection in the first place.

Art's website is *www.artbell.com*. It is exceptionally well run by one Keith Rowland and includes a great archive and lots of links. Keith and I do cross paths every so often at Phoenix-area high tech parties. Keith also runs his own fine website and forum which is up at *www.rowlandnet.com*.

An upcoming competitor to Art Bell is Jeff Renee at *www.sightings.com*.

His website graphics are superb.

Bill Beatty

Bill Beatty honchos an outstanding *Science Hobbyiest* at *www.amasci.com*. As one corner of it, he also provides his broad spectrum of weird science files plus links to absolutely off-the-wall pseudoscience topics.

Topics covered include "click thru" forums, newsgroups, and discussion groups for pseudoscientific topics. Bill also moderates his utterly bizarre *free energy forum*. More details on this at *www.eskimo.com/~bilb/freenrgl/flist.html*.

Keely Net

John Worrell Keely was the turn of the century scam artist who faked free energy perpetual motion machines by use of hidden compressed air lines. Jerry Decker's Keelynet archive up at *www.keelynet.com* is *the* definitive web stash for just about all pseudoscience files and bizarre links.

There are three distinct elements to Jerry's site. The first is a big bunch of leftover classic pseudoscience ASCII textfiles from the old pre-1996 *Keelynet* BBS. These files also do get mirrored elsewhere. The newer archive consists of ongoing news and many links to pseudoscience topics on other sites.

Finally, there is Jerry's odd *Keelynet Mailing List* forum which you can link directly from his website.

Saucer Smear

One of the finest examples of "in your face" journalism that I've ever seen, James Moseley's *Saucer Smear* mercilessly trashes UFO friend and foe alike. His magazine has gotten published continuously for 35 years now. You can subscribe by E-Mailing *slm@well.com*.

Reprints of most issues are up at *www.mcs.com/~kvg/smear.htm*. Or click on my *smear* button at *www.tinaja.com*.

Other off-the-wall UFO websites are *UFO's "R" Us* at *www.qtm.net/~geibdan*. Nevada Aerial's *Leading Edge Research Group* you should find at *www.connec tcorp.net/~trufa*. Or, Glen Campbell's new *UFO Mind* paranormal research site at *www.ufomind.com*.

Borderlands

This is another older pseudoscience establishment. That has been around since 1945. Currently run by Michael Theroux. See *www.borderlands.com*.

Borderlands provides the definitive pseudoscience collection for books, video tapes, audio tapes, and research tools. They also publish the *Journal of Borderland Research*.

"More Miles Per Gallon"

Amazingly, this group is still at it. They apparently have not picked up on the big fact that carburetors are no longer used because these are dirty and inefficient. Nor that the optimum vapor-liquid injection mix is closer to 60 percent than 100, owing to injection mass and

SOME RECOMMENDED WEBSITES

www.artbell.com Art Bell Show
www.tinaja.com/amlink01.html Book access
www.csiop.org/bibliography/home.cgi Book reviews
www.borderlands.com Borderlands Research
www.ufomind.com Glen Campbell
biz.onramp.net/~ceti Clean Energy Technology

www.tinaja.com/consul01.html Consultant's network
www.dejanews.com/home_ps.shtml Deja News
www.newphys.se/electromagnum Electromagnetics
www.exoticresearch.com Exotic Research Conference
www.blacklightpower.com Free energy extraction
www.eskimo.com/~bilb/freenrgl/flist.html Free energy

www.hotbot.com Hotbot search engine
www.padrak.com/ine Institute for New Energy
www.voicenet.com/~eric/dkeptic Eric Krieg
www.connectcorp.net/~trufax Leading Edge Research
www.jse.com Journal of Scientific Exploration

www.iiinet.net.au/~steveb Mad Scientists Lair
www.inette.com/himac Miracle carburators
www.geet.com More miles per gallon
www.overunity.de Overunity devices
www.keelynet.com Pseudoscience forum
www.tinaja.com/pseudo01.html Pseudoscience tutorials

www.randi.org/jr/pigasus.html Pigasus awards
www.tinaja.com/golly01.html Real science tutorials
www.sightings.com Jeff Renee
www.rowlandnet.com Keith Rowland
www.mcs.com/~kvg/smear.htm Saucer Smear
www.amasci.com Science Hobbiest

www.csicop.org Skeptical Inquirer
www.tinaja.com/info01.html Technical evaluation
www.qtm.net/~geibdan UFO's "R" Us
www.tinaja.com/scweb01.html Web site links
www.zenergy.com Zero point energy

required cooling.

Oil companies are often accused of being omnipotent conspirators which have nothing better to do than waltz around shooting people or blowing up the labs of basement inventors to suppress any energy efficiency. Such incidents are far more likely caused through (A) sheer incompetence, (B) mightily disgruntled investors, (C) deliberate self-attempts to bail out from under a bad scene, or (D) pure urban lore that simply did not happen in the manner claimed.

If a miracle gasoline replacement came suddenly upon us, all of the oil companies would virtually certainly react in exactly the same way that the slide rule, the mechanical calculator, typewriter, and minicomputer people did. Using aversion and denial until it was too late. This even has a name. It is known as the *"Rearranging the deck chairs on the Titanic"* syndrome.

An extensive review of the miracle carburetor efficiency claims is found at *www.inette.com/himac*.

Another high profile ongoing research site is Paul Pantone's *GEET Technology* you'll find at *www.geet.com*.

And a Few Others ...

Patrick Bailey's *Institute for New Energy* at *www.padrak.com/ine* has his huge pseudoscience file collection. He also puts on conferences, videos, and lots of reprints.

David Jonsson's *Electromagnum* at his *www.newphys.se/electromagnum* is a Swedish site about his "speculative electromagnetics." Links to the other players are found here.

A somewhat similar German site is at *www.overunity.de*. This one targets free energy research. With overunity theories, RealVideo movies, and lots of external links.

That *Clean Energy Technology* up at *biz.onramp.net/~ceti* is heavy into the *Patterson Cell*. Which seems to me to be yet another example of really bad labwork in the cold fusion area.

Steve Boak runs an Australian *Mad Scientists Lair* that you should find at *www.iiinet.net.au/~steveb*. Steve tries to collect info on alternative technology and free energy machines.

There's also a *Journal of Scientific Exploration* site up at *www.jse.com*. To me it looks like these folks use exactly the same paper, ink, and fonts as you find in a real scientific journal.

Those *Zenergy* folks have a website up, of all places, at *www.zenergy.com*. Apparently the Hazeltine wannabees of the zero point energy movement. Acting as the licensing and clearing house. You'll find lots of papers on zero point energy here.

Skeptical Inquirer

Turning to that other side of the fence, you'll find the *Skeptical Inquirer* at *www.csicop.org*. In which those "real" scientists, writers, and researchers try to debunk the more outrageous of the pseudoscience claims.

Martin Gardner is present with his *Notes of a Fringe Watcher*. And so is The Amazing Randi. Catch his *flying pig* bad pseudoscience awards site up at *www.randi.org/jr/pigasus.html*.

Sometimes, though, I believe they paint with too fat a brush. Overdoing things to the point where they seem to become what they are attacking.

Another high profile pseudoscience bashing skeptic is Eric Krieg found at *www.voicenet.com/~eric/dkeptic*.

Books

First the yeas:

Lindsay Publications offers a fine mix of real and pseudoscience books. The prime focus is older "lost" technology. To reach them, click through on their banner on my website.

Borderlands also has an extensive pseudoscience book collection. That Institute for New Energy provides a more modest one.

The *International Tesla Society* once had a superb off-the-wall bookstore. But this one is apparently in financial reorganization. Sadly, its onetime fine website appears empty. Presumably, some of the slack will get taken up by *www.exoticresearch.com*.

Who, by the way, are putting on (literally) an *Exotic Research Conference* March 25-28 up in Seattle. Featuring many of those "name brand" regulars from their pseudoscience conference circuit. More on what you can expect from conferences of this type at my MUSE124.PDF.

And now the nays:

Skeptical Inquirer has an extensive annotated book review library found at *www.csiop.org/bibliography/home.cgi*.

I've also gathered together some of the main books about pseudoscience bashing. From the skeptic's point of view. You can find more info on these at *www.tinaja.com/amlink01.html*.

Be sure to check these out.

Newsgroups

There are a bunch of pseudoscience newsgroups, but these tend to be the dregs of the Internet. For flamers and trolls run rampant. Their intellectual level rarely exceeds that of any fifth-grade playground brawl. Still, you might find these of interest ...

- alt.alien
- alt.alien.research
- alt.alien.visitors
- alt.aliens.they-are-here
- alt.energy.over-unity
- alt.fusion
- alt.paranet.skeptic
- alt.paranet.ufo
- alt.sex.aliens
- alt.ufo
- alt.ufo.reports
- sci.skeptic

Your best way to search for suitable newsgroup content is through use of *www.dejanews.com/home_ps.shtml*. Similarly, to search the website side of the net, one search engine is *Hotbot* at *www.hotbot.com*. We saw more on this back in RESBN85.PDF.

Preposterosity Du Jeurs

Let's take a quick tour of the more outlandish pseudoscience claims ...

The Magic Lamp — Take two identical light dimmers. Then place a 110-volt incandescent light bulb on your first one and a 32-volt bulb on the second. Now, adjust them both to equal high brightness. Use a cheap enough meter and you will measure one-third the voltage and one-third the current on the 32-volt bulb. Then, you wrongly conclude the 32-volt bulb is nine times more efficient. But do not touch the 32-volt bulb to see if it is any cooler.

What we have here, of course, is *E.E. Student Lab Blunder #01-A* which confuses average and RMS currents.

Low duty cycle waveforms all have amazingly high differences between their average and RMS values. Enough to *exactly* explain the disparity.

The relevant waveforms appear in *MUSE113.PDF*.

I flat out do not see why a patent was issued on a standard circuit from a mainstay chapter of typical 1940's industrial electronics books. There are dozens of other big problems as well, beginning with the circuit's illegality and its instability. To the inherently integrating nature of all incandescent lamps. To theater and mood lighting having never worked.

Amazingly, the device still remains commercially available.

Large Sparking Motors — For several decades now, a large and rather badly sparking motor has been making the late night talk show rounds. Lately, it seems to have reincarnated itself on the motel conference room circuit.

An overunity claim is made based on some supposedly "dead" batteries recharging somewhat when used to power this "free energy" machine. To date, unbiased independent testing appears to me to have been unable to show anything but consistently and abysmally low true motor efficiencies. And popular demo test procs clearly have lacked both scientific rigor and objectivity. *Curiously, the effect seems to go away if batteries are not used.*

I personally believe that we have a bizarre mix here of conventionally explained physics, monumentally bad labwork, and wishful thinking. The bottom line is that electromagnetic theory ain't broke.

If a motor sparks, it *is* inefficient. For the "DC to daylight" energy release in sparking reflects both incompetent design plus a wildly out-of-control *di/dt*. We know for an absolute *fact* that no possible near-conventional motor design can be overunity *unless* fundamental physics gets big-time violated. Considering the very long "looks like a duck and quacks like a duck" pseudoscience history for this device, I'd personally place the odds of anything overunity happening here exceeding 100 billion to one against.

And rapidly rising.

Instead, an unbiased outsider has to ask "Is there some simple and far more likely mechanism with which dead batteries are able to recharge themselves?" Batteries normally "fail" because of rising internal impedance. As long as so much as a tiny scrap of the zinc case remains, some chemical energy theoretically is recoverable. Many years ago, larger dry cells were sometimes extended by opening their top and stirring them.

Thus, we have a probable energy source. With its motive, means, and opportunity.

Simple heating will help. Especially if a higher impedance load matches the internal cell impedance and uses half or more of the available energy to heat the cell. Reverse discharges of large pulses back into the cells may also temporarily undo part of the high internal impedance. In much the same way that electroplating gets reversed every now and then.

You could possibly picture a small $2.00 snap-on "battery improver" cap having a highly efficient switch-mode step up circuit, a storage capacitor, and a power Mosfet or SCR pulser. That, every once in a while, recycles a brief high current blast back into the cell. Said blast to try and reduce the current limiting polarization. Whether such a device would safely and cost-effectively be a way to extract more *net* chemical energy from any battery remains to be shown.

If the proponents of this motor are to be taken seriously, they will have to rigorously separate the motor from the batteries. They will also have to permit competent third-party precise efficiency measurements. Ones made to acceptable industry standards and scientific integrity.

Uh, I do not expect this to happen anytime soon. A lively and ongoing discussion on this topic sometimes appears on Bill Beatty's free energy forum. Most of the rest of the world thankfully (and rightfully) seems to be ignoring it.

The "Transcapacitor" — A year or so ago, a third-tier computer remarketer did start posting all sorts of web docs on "transcapacitors" and other miracle parts. Supposedly recovered from the 1948 Roswell destruction derby.

Even the most casual glance by any engineer immediately spotted this as a monumental advertising hoax. One of the dozens of dead giveaways was that "Plan 9" software firm involved. Ed Wood's *Plan 9 From Outer Space*, of course, was by far the worst science fiction movie of all time.

Computer remarketers are hardly your mainstream well for technical innovation. A case can be made that at least some of them are able to pick up the correct end of any screwdriver something over 49 percent of the time. Further, there is an incredibly great new history book titled *Crystal Fire* by Michael Riordan which inadvertently but utterly and thoroughly refutes all these alien technology claims. More at *www.tinaja.com/amlink01.html*.

Great heaping bunches of gullible UFO enthusiasts sure got sucked in on this one. Several of them went into their "shoot the messenger" mode.

Fractional Energy States — It is quite important not to blindly attack any apparent pseudoscience with a manic religious fervor. It's also crucial to not dismiss new claims out of hand. So this scheme may or may not turn into something. But I seriously doubt it.

An apparently credible mainstream researcher believes that a fractional energy state exists which allows "free energy" extraction. You can evaluate these claims for yourself by viewing *www.blacklightpower.com*.

To me, this seems like yet

another rerun of the cold fusion fiascos. And it has been around enough now that, if something was there, others would have surely explored it by now. My prediction is that there'll be a failure to independently duplicate. Mixed in with the usual bad labwork or subtle misinterpretations.

The pseudoscience claims involving overunity hydrogen electrolysis are a world unto themselves. We'll look at these in a future column.

For More Info

Several interesting pseudoscience websites are gathered together in the nearby sidebar. Necessary and useful tools to let you intelligently evaluate pseudoscience claims appear at my *www.tinaja.com/glib/bashpseu.pdf*. The tools let you separate all those useful adjuncts towards porcine whole body cleanliness from the total hogwash.

I have several areas on my *Guru's Lair* website devoted to pseudoscience topics. Links to the above sites and many others can now be found at my *www.tinaja.com/scweb01.html*, while a library of pseudoscience tutorials are now at *www.tinaja.com/pseudo01.html*. Meanwhile, the "real science" stuff that focuses on fundamentals is found at *www.tinaja.com/golly01.html*.

Some tutorials on proper AC power measurements and thermodynamic fundamentals also appear elsewhere on the site.

Custom research services that will assist you in evaluating the legitimacy of technical claims can be found at *www.tinaja.com/info01.html*. Additional consultant networking is located at *www.tinaja.com/consul01.html*.

This Month's Contest

As our contest for this month, just tell me a bizarre pseudoscience story. Or show me any off-the-wall resource that I don't already know about.

There'll be a dozen or more of my new *Incredible Secret Money Machine III* books going to the better entries. And an all expense paid *tinaja quest* for two (FOB Thatcher, AZ) going to the very best entries of all.

Send your written and snail-mailed entries on this contest directly to me here at *Synergetics*. **NV**

Microcomputer pioneer and guru Don Lancaster is the author of 35 books and countless tech articles. Don maintains his no-charge US tech helpline found at ***(520) 428-4073****. The best calling times are 8-5 on weekdays, Mountain Standard Time.*

Don is the webmaster of his Guru's Lair found at ***http://www.tinaja.com****. You can reach Don at Synergetics, Box 809, Thatcher, AZ 85552. Or send any messages to* ***don@tinaja.com****.*

Continued from page 38

have a bad filter capacitor allowing the tone to transfer from one section to another via the power lines.

Is the tone different for different frequencies? If so, it may be one of the counter stages feeding back. (3.5 MHz, divided by 10 for first digit, and again by 10 for second digit and so on, one of these may come up in the audio range, and feed into the audio section of the receiver.)

Again, the common power connections may be the path where the signal is being fed back.

One other possibility is the local oscillator of the counter (many use color burst crystals in the 3.5 MHz range). This could be beating with the BFO oscillator causing a tone, but should only occur near the frequency of the oscillator in the counter, and go out of the passband of the receiver as you move one side or the other of the oscillator.

Unless you are just unlucky enough to want to listen at a frequency near this timebase oscillator, or one of it's many multiples.

This is usually a squarewave and the rapidly rising edges cause harmonics across the band. Isolating and shielding the counter may help, but with the sense probe being connected to the radio, that one is difficult to shield. The timebase oscillator should present minimal problems, if this turns out to be the case, except at or near the timebase or one of it's harmonics.

Ed Pruitt
Keller, TX

ANSWER TO #2999 - FEB. 1999

It sounds to me like you want to substitute the digital pot for the potentiometer that the Elenco function generators have. http://www.ionet.net/~bschwabe/BasicStampII/StampII-to-AD8803.gif has a BASIC Stamp schematic that shows how to hook up and Analog Devices digital part to a PIC microcontroller, and this page: http://www.ionet.net/~bschwabe/BasicStampII/Communication/0005.html shows how to connect a PIC microcontroller to an RS-232 port.

It also shows Qbasic code to handle the communication. Analog Devices makes other digital pots if this one doesn't meet your needs, as does Dallas Semiconductor and Xycor.

Tom Tillander
Bay Village, OH

ANSWER TO #2998 - FEB. 1999

If you are going to put up an outdoor shortwave antenna, you're headed for a lot of fun! The easiest receiving antenna to put up is a wire in your back yard. You'll need stranded copper wire for the antenna itself, insulated lead-in wire, two insulators, a window feed-through strip, and either strong wire or rope to support the antenna.

RadioShack sells the entire kit (minus the supporting wire or rope) for $10.00, # 278-758.

Fasten one supporting wire or rope to your house, as high as possible. The other end of the support goes to one insulator. Fasten one end of the stranded copper wire to the other end of the insulator, and solder one end of the lead-in wire to it (after stripping the insulation off the end).

The other end of the stranded wire goes to the second insulator. Fasten the second support wire or rope to the other end of the insulator, and attach it to a tree or pole, at least high enough so that no person running in the yard could catch his neck on your antenna.

Place the window feedthrough strip on the window sill and close the window on it. Cut the lead-in wire to the length needed to reach the outdoor connector on the feedthrough. Strip the end of the wire and connect it to the feedthrough. Strip both ends of the remaining lead-in, and connect one end to the indoor side of the feedthrough and the other end to your shortwave set.

If you don't already have a shortwave receiver, be sure to buy one with a Beat Frequency Oscillator (BFO) so you can listen to hams, as well as international broadcasts. I started listening when I was 13, and within a year I had my ham radio license!

Shortwave radio is a fascinating hobby, and if you do become a ham, all you'll need to transmit on your antenna is a better feedthrough and a wide-range antenna tuner.

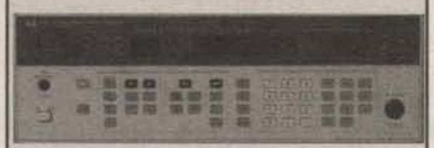
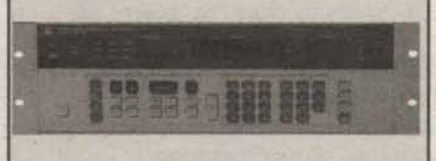
John J. Herro
Palm Bay, FL

New Year

Pacific Test Equipment

BLOWOUT SALE

PACIFIC
TEST EQUIPMENT

	**HP 8657A Synthesized Signal Generator** 0.1 - 1040 MHz with 10 Hz Resolution, +12 to -143.5 dBm 50W Reverse power protection, internal AM/FM Modulation Note: RF Connectors on rear panel (opt. 002)	Retail $9,995 Regular $5,900 **Sale $1,650**
	**HP 8656B Synthesized Signal Generator** 0.1 - 990 MHz with 10 Hz Resolution, +13 to -127 dBm 25W Reverse power protection, internal AM/FM Modulation Note: RF Connectors on rear panel (opt. 002)	Retail $7,900 Regular $4,250 **Sale $1,250**
	**HP 5334B Universal Counter** 0 to 100MHz, 9 digit per second resolution, rise/fall time, pulse-width, ac/dc voltage measurement. Frequency, period, ratio and time interval. Front and rear inputs in parallel. HP-IB	Retail $2,305 Regular $1,000 **Sale $195**
	**HP 3457A Digital Multimeter** 3-1/2 to 6-1/2Digit with extended resolution to 7-1/2 digits. dcV, acV, dcI, acI, Ohms, frequency and period.1350 readings/sec. at 3-/2 digits. HP-IB	Retail $3,260 Regular $2,495 **Sale $695**
HP 3562A Dynamic Signal Analyzer Frequency range 64μHz to 100kHz. Network, spectrum, waveform and transiet analysis. 80dB dynamic range. FFT. HP-1B		Regular $9,500 **Sale $4,550**

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ELECTRONICS Q & A

With TJ Byers

In this column, I answer questions about all aspects of electronics, including computer hardware and software. This column doesn't replace the Tech Forum that you've grown to love and support. Instead, it will supplement it, so feel free to participate as always with your questions and answers. You can reach me at TJBYERS@aol.com, TJBYERS@juno.com or by snail mail at Nuts & Volts Magazine, 430 Princeland Ct., Corona, CA 91719.

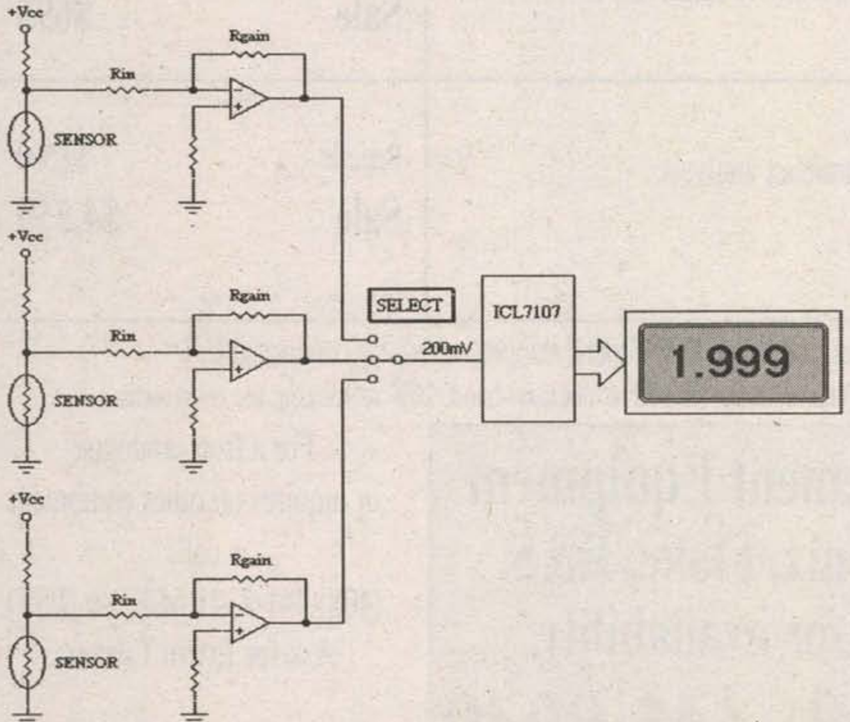
What's Up: LED and LCD displays, where to buy, how to apply. Lots of circuits, from audio filters to winning choices. Where to find obsolete ICs, and the perils/benefits of a computer upgrade. Finally, a fix to a previous answer (hey, nobody's perfect!).

LED Thermometer

Q. You have published several articles recently detailing how to interface an LCD display to a PIC or similar device. My need, however, is for an LED or vacuum fluorescent readout. I tow a trailer with my truck and need to display actual temperature readings (not idiot lights) from coolant, automatic transmission, and differential lubricants (all resistive sensors). Can you suggest a document or book that can tell me how to do this with a typical PIC or similar device? (I suspect this is more complicated than could be easily explained via your usual column.)

Earl B. Jackson
via Internet

A. *Yes, the complete answer is a bit beyond the scope of this column, but I can steer you in the right direction. For one thing, you don't need a PIC to accomplish your goal. What you do need, however, is some kind of analog-to-digital converter – like a simple DVM (digital voltmeter) chip. A good choice is the ICL7107 that you can buy from Digi-Key (1-800-344-4539; http://www.digikey.com) and just about anyplace in town for under $10.00. This chip drives a 3-1/2 LED display and requires just 10 external parts. Here's a block diagram of what you're trying to do.*



As you can see, the hardest part is scaling the input voltage so that the display has the same numbers as the temperature output from the sensor. This is done via the op amp by scaling the amplification and offset voltage accordingly. For complete details, download the ICL7107 data sheet from the QuestLink Website (http://www.questlink.com). You can also order the IC from their Web site for a very low $3.68. I've used a selector switch to limit the cost by switching from one sensor to the next. If you wish, you can use a separate ICL7107 and LED display for each sensor, thereby creating an instrument cluster.

Still want to use a Stamp microcontroller? No problem. Check out Scott Edwards July '97 column for ways to turn temperature into digits using an LM34 and a ADC0831 A/D converter. While the original design used an LCD display, it's easily adapted for LED. This article and other items of interest are available from www.nutsvolts.com in the Stamp Apps FTP directory. Back issues of N & V are available from the snail mail address above for $5.00 postage paid.

Unique LCD Displays

Q. *I have invented a game that I'd like to market, but it needs a custom LCD display. Do you know of a place where I can order custom LCD devices? I can't find one.*

Matthew J. Maberino
via Internet

A. *Here's a listing of the custom LCD sources that I'm aware of.*

All Shore Industries *– (1-800-959-0548; http://www.allshore.com/)*
Crystaloid *– (1-888-237-8523; http://www.crystaloid.com/)*
DCI *– (913-782-5672; http://www.dciincorporated.com/)*
Densitron *– (562-941-5000; http://www.densitron.com/)*
Ocular *– (972-437-3888; http://www.ocularusa.com/)*
Kent Displays *– (330-673-8784; http://www.kentdisplays.com/)*

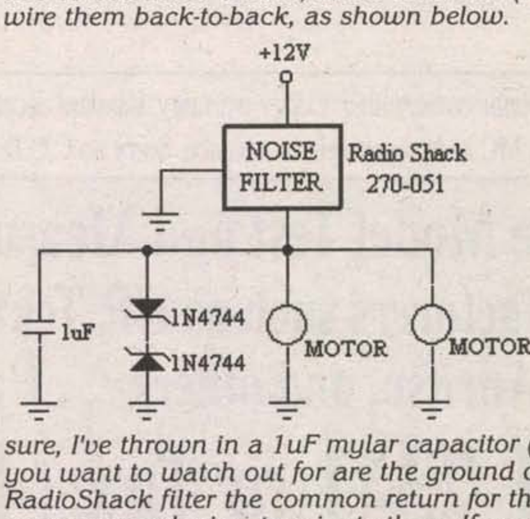
The last, Kent Industries, is the most interesting because it requires no power except to change the display information. Once programmed, the display can hold its image for days, weeks, and even years with no refresh. This may be a shortcut to setting up your game screen display, as in cut-and-try, before committing it to a production-run version.

Eliminating Motor Noise

Q. I am using 12-volt, 5-amp windshield wiper motors in a computer-controlled robot. However, the computer suffers from interference from the motors when they are activated. Can you suggest some sort of filtering? I've seen capacitors soldered across motor leads. Is this what I need? What size capacitors should I use?

Ken Delahoussaye
via Internet

A. *I suspect the problem isn't with the motor itself, but the reverse switch inside the motor that causes the sweeping action. Basically, it reverses the current through the motor windings, which I think is causing an EMF (reverse voltage) spike. Here's where I'd start. Take two 15-volt zener diodes, like a 1N4744A (RadioShack 276-564), and wire them back-to-back, as shown below.*



This arrangement prevents the EMF from exceeding 15.7 volts, which will reduce the noise a lot. However, you'll probably need a hash filter, too. I suggest RadioShack's 270-051 ($14.99), which includes a choke and bypass capacitor. One filter should serve all your motors if you wire it as shown. For good measure, I've thrown in a 1uF mylar capacitor (non-polarized). One thing you want to watch out for are the ground connections. I'd make the RadioShack filter the common return for the battery and have all the power ground wires terminate there. If you don't, a ground loop may occur that will create further problems. In other words, run a separate wire from each ground point to a common ground; don't daisy chain the wires. The resistance from wire to wire, albeit small, is where you get current loops when you daisy chain. ABOVE ALL, make sure to use one ground point for the digital electronics and a different ground point for the analog components, like your wiper motor. It's okay to tie the analog and digital ground points together via a single, heavy wire – you just can't use one ground point for both. You must also

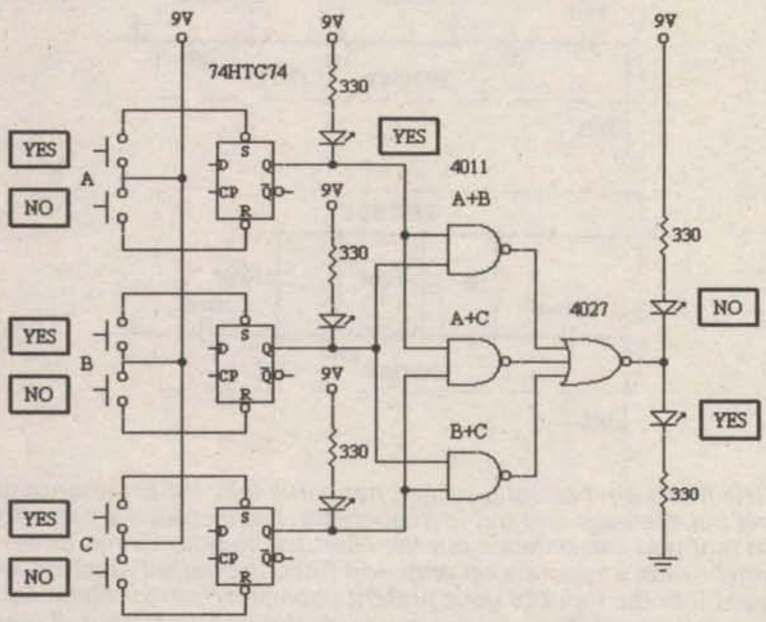
bypass the Vcc power supply to the ICs using a 0.1uF capacitor. One capacitor is required for each chip, and it has to be placed as close to the IC power input pin as possible.

And The Winner Is ...

Q. It's my job, along with two colleges, to view slides of submitted art work for consideration in exhibitions. As the slides parade across the screen, we cast our votes on paper, which are later tabulated and sorted — a very tedious and time-consuming task. What I'd like is a circuit that would display and record our results, both as a group decision and individual votes, as each slide comes up. Is this easily done using a surplus numeric keypad or ...?

Steve Lawrence
via Internet

A. *Displaying the results are easy; printing them out is harder, and not something I want to tackle in the short space I have. So what I've done is create a voting machine that reduces the number of steps required to tabulate the votes.*



Since there are only three voters, I'm using simple logic to decipher and display the votes. As you see, there are only six combinations, which can be reduced to three formulas.

$$A + B \qquad A + C \qquad B + C$$

Your yes or no vote is entered via two push-button switches, like RadioShack 275-1547. Alternatively, you can use a center-off toggle switch, like RadioShack 275-652. When the yes or no button is pushed, it sets the output of the 74HCT74 flip-flop high or low (depending on your choice), and locks in your decision so that you don't have to hold the button down. If the answer is yes, the corresponding LED lights. The outputs of the three flip-flops are processed by three NAND gates (4011). Each gate tests for one of the equations above. When the equation parameters are valid, the output of the NAND gate goes high, indicating a majority or yes vote. The 4027 NOR gate buffers the outputs and drives the Yes and No LEDs. For the Yes LED to light, at least two votes have to be yes, as per the equations. Now all you have to do is transfer this information to a paper form using checkmarks, as shown below.

SLIDE	#1 YES	#2 YES	#3 YES	YES/NO
101	Ö	–	–	N
102	–	Ö	Ö	Y
103	Ö	Ö	Ö	Y
104	–	–	–	N

To automatically print out this data, you'll need a computer, a parallel or serial port I/O interface circuit, and a software program. The I/O interface can be any internal or external card, like those we've published in the past (see "Mailbag" below). Personally, I'd use the game port and have the LEDs activate a respective game-port "fire" button. A simple QBasic program can sort out the votes and save them in tabulated format in a text file, which you can print. Yes, it's really that easy – if you have a PC. This can also be done using a Stamp microprocessor; contact Scott Edwards Electronics at 520-459-4802; http://www.seetron.com) for details. If your voting panel expands to four persons, I'd change the design from digital to analog using a summing op amp (write me if you're interested).

Obsolete Chips Don't Die, They Go To Surplus Heaven

Q. I want to tie the video output of my webTV (RCA jack) to the RF input of my TV set. I assume the output is standard composite that must be translated to channel 3. Got a design? Also, where can I go to find hard-to-obtain ICs? I'm looking for a Toshiba TA7679P.

Gus Calabrese
via Internet

A. *It's funny that you should bring up two seemingly unrelated questions at the same time. Actually, they're quite related. You're absolutely right in that in order to tie the output from your webTV to a TV set, you have to convert the composite signal to a channel 3 or 4 RF signal using a modulator. Once upon a time, when Atari and Commodore PCs were popular, you could buy RF modulators for almost nothing. Now that most PCs use VGA or superVGA, their usage has shifted to video surveillance cameras and DSS applications. With the shift came more complexity and higher prices. Fortunately, you can still get a reasonable deal from RadioShack. Their model 15-1244, with automatic switching, sells for $29.99, and the manually-switched RSU 12016507 goes for just $19.99.*

You're probably wondering why I haven't dusted off an old resource book and conjured up a DIY schematic. Well, it's because the chips used in those designs are long obsolete. The popular ones were the LM1889 and LM2889 from National Semiconductor. Today's RF modulator ICs are either computer controlled (TDA8822) or operate in the cellular phone 900 MHz band. The LM2889 is still available, as is the TA7679P, but from a select few outlets. Here's a list of the obsolete IC vendors that I'm aware of. (If you happen to locate an LM2889, you can still download a data sheet and application note from QuestLink at http://www.questlink.com and make your own RF modulator.)

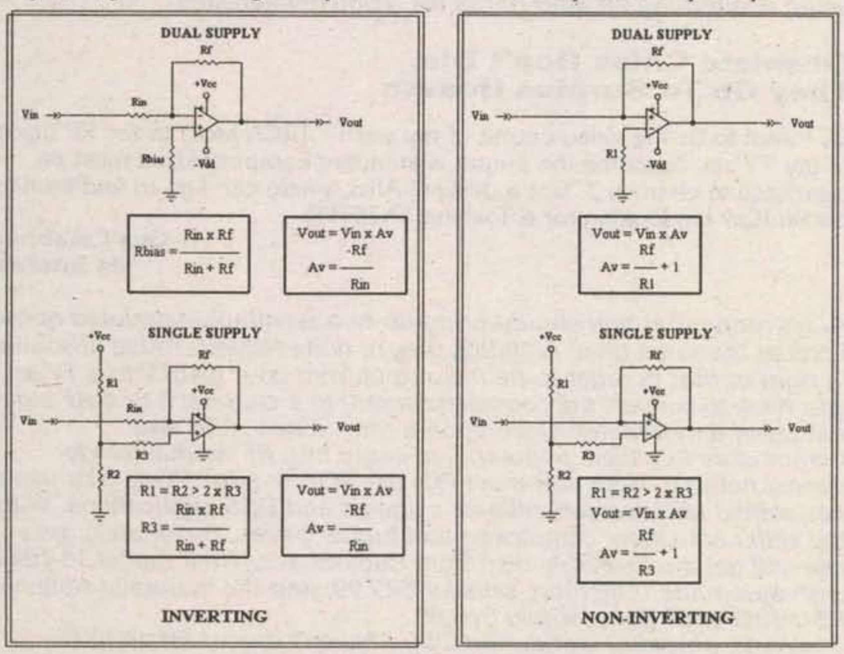
Just In Time ICs *– 510-490-1377; http://www.batnet.com /justintime/JUTIC.html*
D.R. Components *– 561-274-8840; http://www.drcomponents.com /stockcheck.html*
California IC Company *– 805-526-7117; http://www.calif-ic.com*
Onlinetechx *– 813-367-2512; http://www.onlinetechx.com*
Chip Directory *– http://www.ba-karlsruhe.de/chipdir/obsolete.html*

Op Amps And Filters Go Together

Q. I have an electronic light organ board that I bought from Fry's Electronics. The color organ works fine, but at low volumes there isn't enough power to activate the triacs on the board, so the lights flicker. I need a stereo amplifier that will take in about half a watt and amplify it to about two or three watts. Instead of taking the easy way out and buying a kit, I want to make it myself. Can you provide me with a schematic of this amplifier? I have one more question about the color organ. While there are three channels on the board for bass, mid, and treble, the capacitors provided do not work very well — in fact, they don't work at all in filtering the sound. Can I make a simple filter with capacitors and resistors that will enhance the frequency-separation effect?

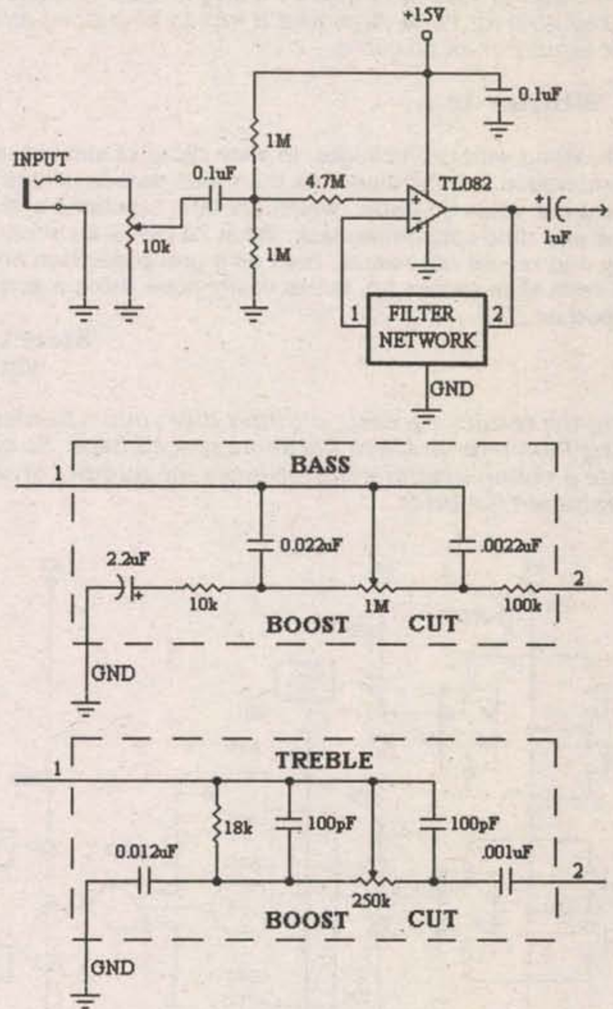
Edvis Shahbazian
via Internet

A. *The problem isn't lack of power, but not enough voltage. Power is the produce of voltage and current (P = EI), so as you reduce the volume you are also reducing the output voltage. You don't need a power amplifier, just a voltage amplifier — like an inexpensive op amp.*



There are two common configurations for an op amp, inverting and non-inverting, as shown above. Simply put, the inverting configuration outputs a signal that is 180 degrees out of phase with the input, while a non-inverting amplifier keeps the two in phase with each other. Which to use depends on what you plan on doing with the amplified output. For most audio applications, the non-inverting configuration is used. Instrumentation and servo circuits often use the inverting configuration, which provides unity gain and negative amplification (attenuation). It's simple enough to calculate the gain (Av) needed for your application by measuring the output voltage of your audio source using a DMM in the AC mode. First measure it when the lamps are pleasing, and at the point where they start to flicker. Divide the higher voltage by the lower, and there's your amplification factor. Now choose a value for resistor Rf and run it through the equations.

As for creating a better filter using capacitors and resistors, it can be done using the same op amp. Basically, what you do is replace the Rf feedback resistor with an RC network, as shown.



The filters are basically pi-type networks that either enhance or cancel out the bass and treble frequencies. I've included a potentiometer so that you can balance out the channels to your liking. Each channel needs a separate op amp and filter, the output of which is plugged into the input of your present capacitor/resistor filters on the color organ board. The mid-range can go through unfiltered, if you wish.

Computer Upgrades: The Good, Bad, And Ugly

Q. I have two questions that maybe you might be able to answer. First, I get the following error message when trying to download from sites as your ftp library: "Error Locating Object Handler...there is no viewer available for the type of object you are trying to open." It didn't always happen, so I believe I have a configuration problem. I'm sure it started after installing another software program, possibly AOL 4.0, which I use with Win 98 and Explorer 4.0.

Second, I have upgraded my system by installing a new motherboard. The problem is that I now can't use the original software that came bundled with my Packard Bell computer. It seems to be looking for some

BIOS information that it can't find. Thanks for any help you can provide.

Mike Maberino
via Internet

A. *Let's take the second problem first – where you installed a new motherboard. That means the BIOS doesn't have the cues that the Packard Bell software is looking for. Often OEM (original equipment manufacturer) software puts a bit of its code in the BIOS (many DOSs, for example). This prevents you from giving away the programs to all your friends and neighbors for free. By upgrading the motherboard, you lost this thread of code. Can you plug your old BIOS into the new motherboard to set things right? Unfortunately, no. There's another possibility, too. Often software is loaded onto your hard disk from a master. To, again, keep you from spreading free software around the neighborhood, the master places a special code on the hard disk in a hidden file. If this file is erased or corrupted, the software won't run.*

Now let's take up the issue of AOL 4.0. It sucks! My girlfriend installed it on her Windows 3.1 hard disk and it ate the D: drive – literally. It turned the entire drive into one big file! Next, I tried installing it on a Windows 98 hard disk, and it turned those files to mush, too. So it's possible that AOL 4.0 may have corrupted portions of your hard disk, which is causing you problems. I've had similar complaints from other readers who have AOL 4.0 with problems like you describe, so this isn't an isolated incident. Don't get me wrong, AOL 4.0 has to work a lot of the time, or AOL wouldn't keep "selling" it. I've phoned and E-Mailed AOL tech support repeatedly, but to no avail. Let's hope the pen is mightier than the phone and we'll get an answer to this problem.

(Mike's reply: Thank you for all your help. I did discover that the object loader it's looking for is an Unzip program. It appears that the Zip magic program I had installed previously corrupted my plug-ins, not allowing it to find PKware or the AOL unzipping program. As far as the new motherboard, I will have to work on that problem. I did notice that some of the bundled software from Packard Bell has either a GTS or GTZ extension, like that which appears on some Doom files. This is where they put programs like MSOffice, too, so I can't retrieve those either. It appears that they require a special expander or uncompressor utility which I can't find. Oh well, I'll keep trying.)

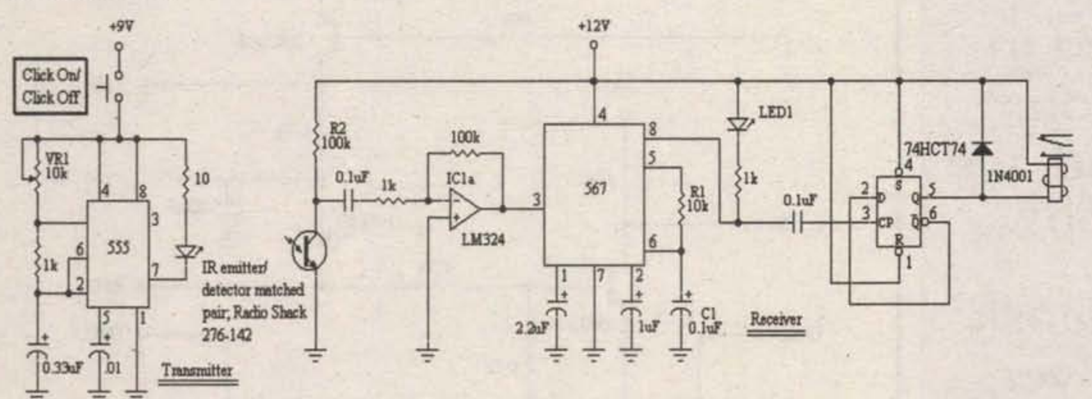
(Readers: can you help me here? Despite repeated calls to Packard Bell, I don't know which utility Mike needs to unlock his files. My thought is that it exists on a master CD-ROM. Thanks! – TJ Byers, Q & A Editor)

Hey, It Doesn't Work!

Q. In the July '98 issue you had a design for an infrared remote as a response to a request by Mr. Shadrick. It was termed a "classic design ... almost a classroom exercise." In my electronics class we have tried this design a couple of times. While it looks very straightforward, we had a spectacular lack of success! There seem to be some glitches in the transmitter, but even after trying to correct them, we are still unsuccessful. Are there any changes from the original design? Are there any tests that you can recommend with basic tools, like a scope or DMM? It looks like an ideal add-on project to car alarms etc., once we get it going reliably

Andy Blumel
via Internet

A. *Yes, I screwed up on that circuit – simply because I never built and tested it. If I had, I would have discovered that the latching circuit, which I plucked from one of my reference books, doesn't work as advertised. It simply locks up, and no amount of triggering can shake it loose. Here's an amended circuit that I know works – I tried it! Sorry for the inconvenience.*



Hubby Wants To Share Printer

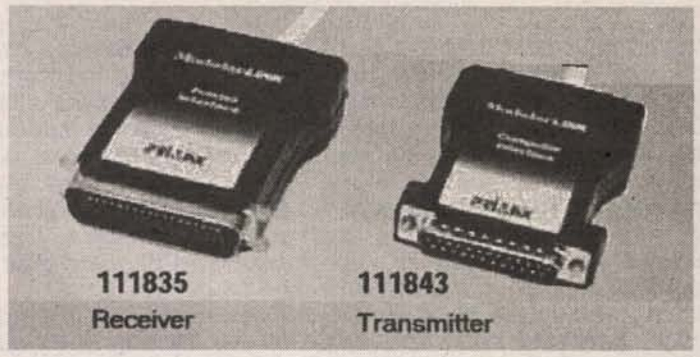
Q. I would like to establish a LAN between my wife's computer and my computer to enable both of us to use one good printer. However, her computer is a notebook which has a PCE 10BASE2 PCMCIA (PC Card) LAN card with a coax connector. My computer has a PCI 10/100BASE-TX card that uses twisted pair com line with an RJ45 connector. Can I connect the two together with a LAN balun that has a 50-ohm BNC on one end and a 600-ohm RJ45 on the other?

Charlie K3VDB
via Internet

A. *Well, it's not as simple as winding a balun coil for several reasons. As you point out, one uses a BNC connector and the other an RJ45 phone plug. The first is a single-ended signal, and the other is a twisted-pair differential signal. In the short-wave world, changing from one to the other is a simple matter of inserting a balun transformer, and grounding one of the leads. Not so with LANs. Not only are you dealing with grounded versus ungrounded signals, but topology and protocol issues as well.*

What I'd do instead of trying to tie the two PCs together via Ethernet is to purchase an inexpensive switch box located at the printer. The type of switch box depends on the printer and the distance from the PC. If it's an HP or similar printer with a parallel input, located within 20 feet of the PC, I'd use a simple two-way DB25 switch box, like the $7.95 155512 from ***Jameco (1-800-831-4242;*** *http://www.jameco.com). For distances over 25 feet, you'll want to use a serial connection, which may require you to convert your parallel port to serial and back to parallel again using the Primax Instant Printing Network. This system lets you connect up to 16 PCs to a single printer over distances of 1,200 feet using phone cable and RJ11 (phone) connectors. You'll need a receiver Jameco (111835, $44.94) at*

the printer site and a transmitter (Jameco 111843, $39.95) for each PC.



MAILBAG

Hi TJ:

Thanks for including my Reader's Tip in the Nov. '98 issue. Unfortunately, several additions have been added to the original schematic, resulting in two major problems.

Specifically, the voltage supply circuitry in the upper left was not on the original, and its purpose is not clear. My original intent, as described in the text, was that the +5V would come from the processor board on which the circuit was built, and therefore not draw power from the host PC. I guess some of this confusion probably stems from my text saying "the circuit 'steals' its power from the host serial port" whereas it should more appropriately have said "... 'steals' its negative voltage ..."

Second, and much worse, is the addition of the DB9 connector to my original schematic. It is located on the WRONG side of the circuit! As described in the text, the TxD and RxD lines go to the host serial port, while the TD and RD lines (originally labeled Tc and Rc) go to the local CPU. This has caused a lot of confusion with people who have E-Mailed me about the circuit.

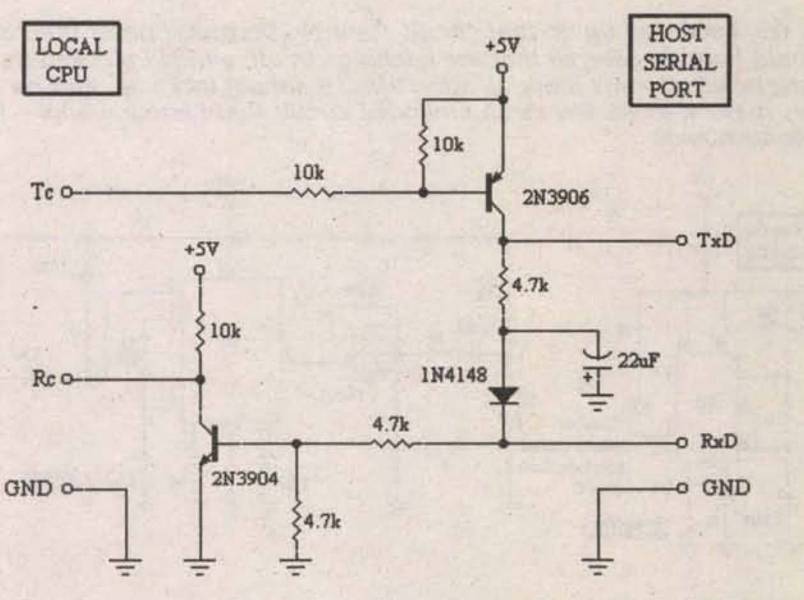
So, I think we need to publish some kind of correction to straighten things out. Again, thanks for publishing the circuit.

Dan Michaels
Oricom Technologies
oricom@lynx.sni.net

Response:

Sure! Here's the circuit in its original form, with added nomenclature to identify the ports.

TJ Byers
Q & A Editor



Dear TJ Byers:

Thank you very much for answering my question concerning the Sun Sparc 2 monitor ("Sun to PC Monitor," Jan. '99). Next question: Where can I find the 13W3 connectors if I want to make my own adapter cable?

Howard Lee
via Internet

Response:

***Newark Electronics at 800-463-9275**; http://www.newark.com. They range in price from $5-$9 each. Also **Allied Electronics**, but you'll have to call them **(1-800-433-5700)** because I can't find this item in their on-line catalog; I know they stock it. I suggest you check out your local computer swap meets, too. You'll likely find what you're looking for at dirt cheap prices.*

TJ Byers
Q & A Editor

Continued from page 7

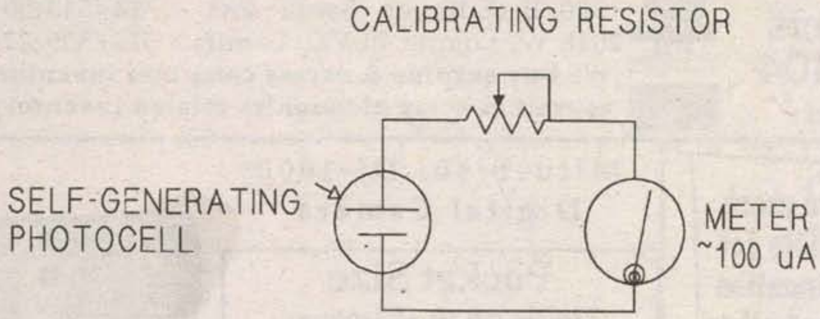


FIGURE 1.

EARLY FORM OF LIGHT METER USED PHOTOVOLTAIC CELL, RESISTOR, AND METER. MEASURED LIGHT IN TERMS OF VOLTAGE.

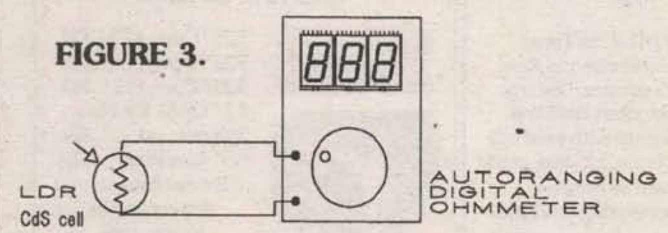
ing too fancy there. The meter shown in Photo C, comes from RadioShack. The photo shows the final analog version, with slightly different values than shown in Figure 7. The drawing gives values for other common meters that you may have in your spare parts box. It shows a CdS cell, although a photo transistor will work too. You can pick up either when you get the meter and the regulator.

Scaling

The analog meter, Figure 7, uses two range resistors labeled Inside/Outside. On the Inside range, a relatively small current will give a moderately large voltage drop driving the meter toward the upper end of the scale. In other words, it is sensitive enough to use indoors. The Outside range needs more light to get the same deflection on the meter. That makes it suitable for high light levels. Thanks to the regulated power supply, it will give consistent, repeatable readings.

Perhaps a 10-to-1 resistor change would have given somewhat better correlation between scales, but I wanted more sensitivity on the Inside range and not have sunlight drive the meter hard into the pin. By experimenting, I found the resistor that gave the results I wanted on the outside range; likewise on the inside range. The three least sensitive ranges on the digital system have semi-respectible correlation.

FIGURE 3.



SIMPLE BUT EFFECTIVE LIGHT METER

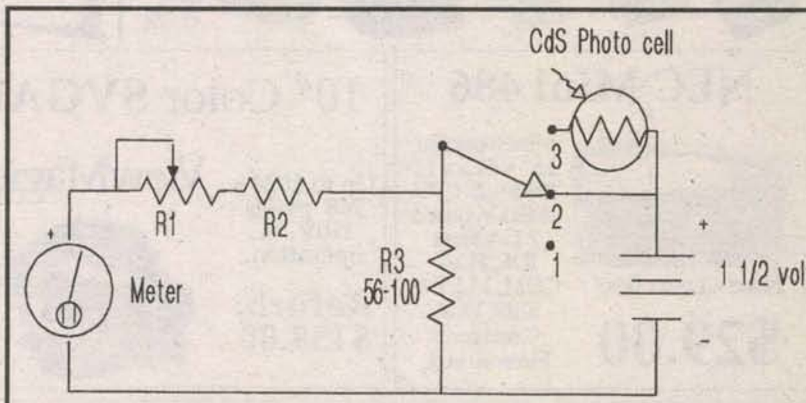
While you can make a simple light meter with either an analog or a digital meter, you need a calibration chart for film speed and light levels. The autoranging digital meter shows changing light levels in terms of resistance and changes ranges as needed when you change back and forth from the inside to the outside, or as clouds cover the sun. Of course, an analog VOM will work here, too.

How and Why

With either sensor — the CdS cell or the photo transistor — when light strikes the sensitive surface, the resistance between the terminals goes down. That feeds more current into the range resistor. That puts more voltage across the meter circuit which indicates a higher light level. The digital version, Figure 8, lends itself to a wider range of light levels and therefore has five range resistors. It will read extra low light levels due to the amplification built into the digital display. Some of the range resistors cut the sensitivity so that you can use it in bright sunlight.

Spectrum

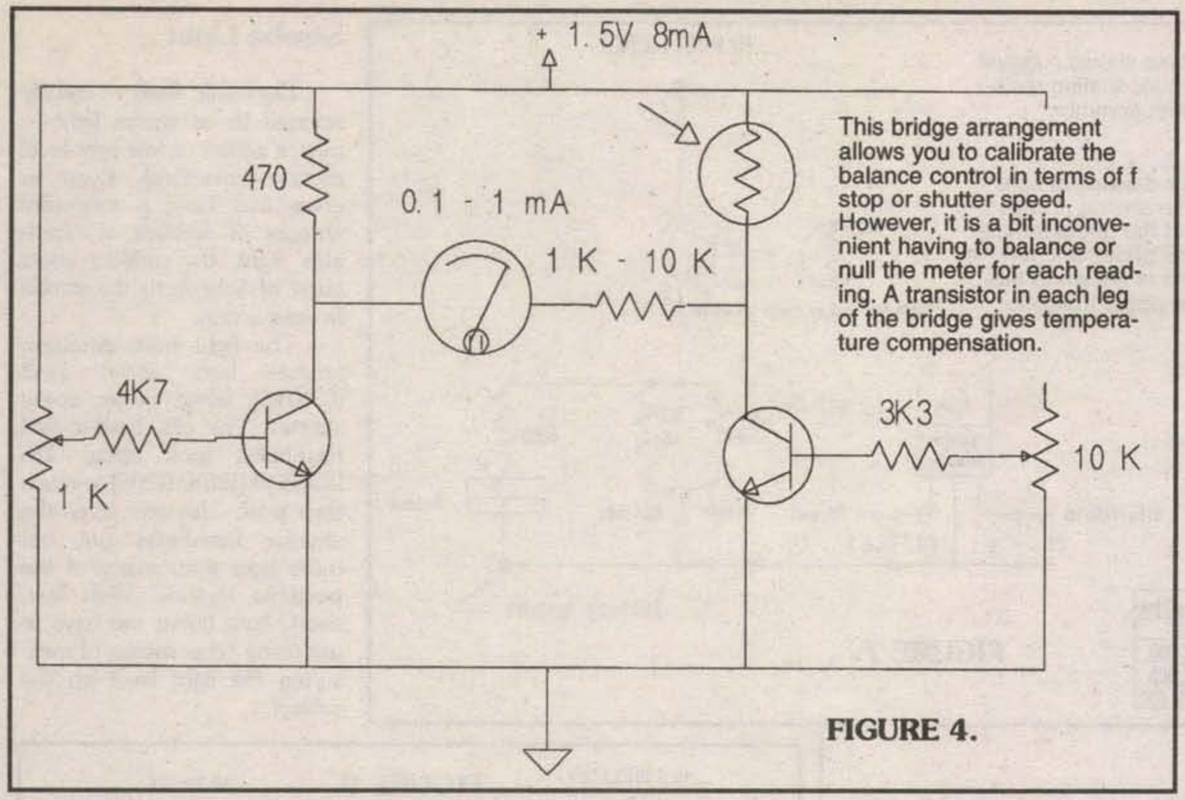
So far, I have mentioned that you could use either the cheap, common CdS photo cell or the easy to get photo transistors. Keep in mind that the two types of cells respond, or should I say do not respond, to all wavelengths of light the same way. While both of them will register something in the realm of visible light, the most readily available photo transistor works quite well in the infrared part of the spectrum. The CdS cell barely responds to IR. At least, when I pointed a TV remote control at it, it practically ignored the signals. The photo transistor drove its readout to a high reading. An alternative



METER	R1	R2
1 MA	1000	1000
100 uA	10K	10 K
50 uA	20 K	20 K

MEASURING LIGHT IN TERMS OF RESISTANCE WITH ANALOG OHMMETER AND LIGHT-DEPENDENT RESISTOR.

FIGURE 2.



This bridge arrangement allows you to calibrate the balance control in terms of f stop or shutter speed. However, it is a bit inconvenient having to balance or null the meter for each reading. A transistor in each leg of the bridge gives temperature compensation.

FIGURE 4.

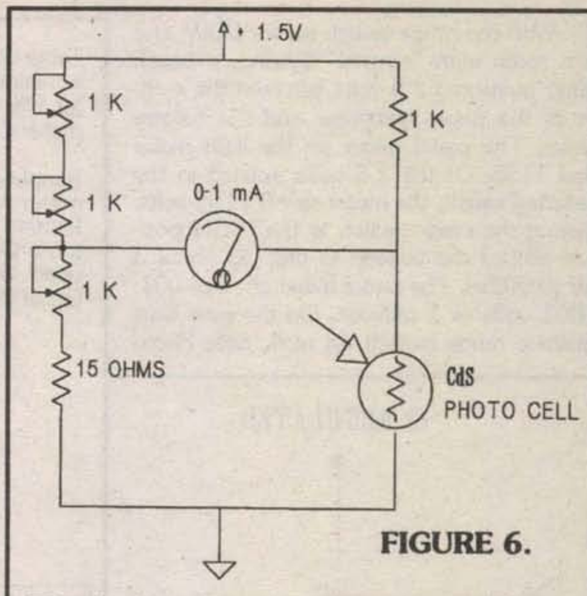


FIGURE 6.

This circuit would let you calibrate a control for film speed, another for f stops, and one for shutter setting. However, it too has enough drawbacks to render it less than real practical.

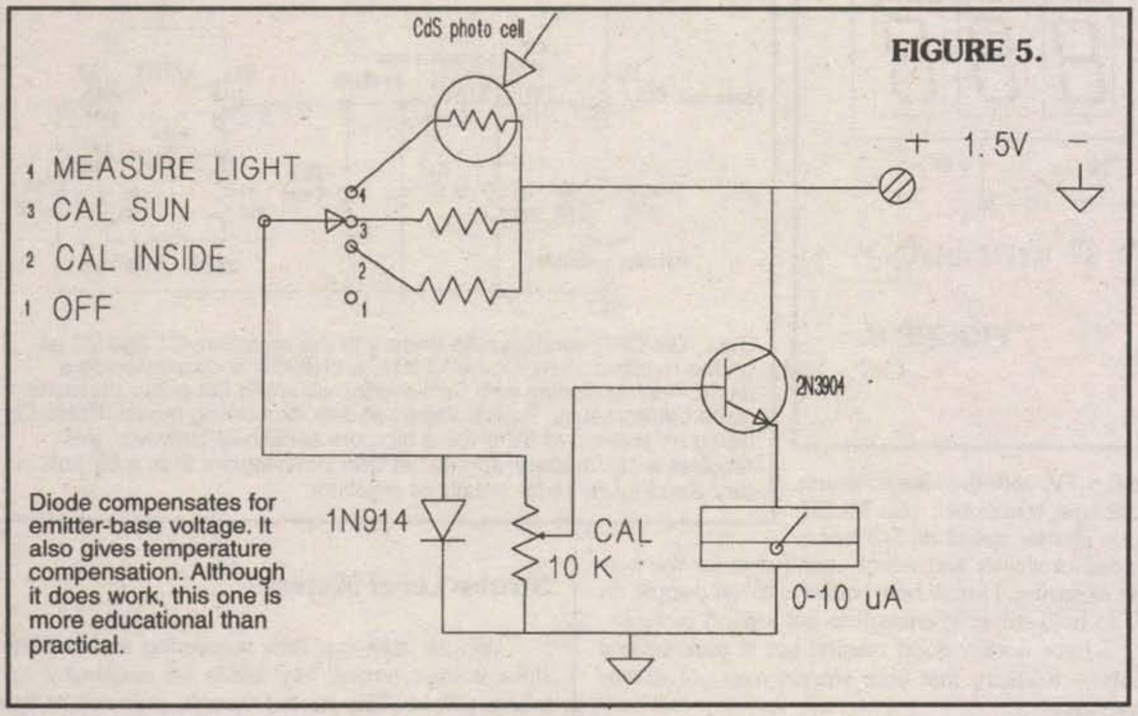


FIGURE 5.

Diode compensates for emitter-base voltage. It also gives temperature compensation. Although it does work, this one is more educational than practical.

light measurement that you may find useful, practical.

Digital Variations

The common digital panel meters with Liquid Crystal Display MUST have a separate battery to power them. You CAN NOT make any connection between either of the battery leads for the meter and the rest of the circuit. You will have to ask the manufacturer why. Some types of LED DPMs will let you use a common power supply, but, for my money, they draw too much current for a portable instrument. Of course, if it suits your needs, at the expense of heavier batteries, or shorter battery life, you could use an LED display.

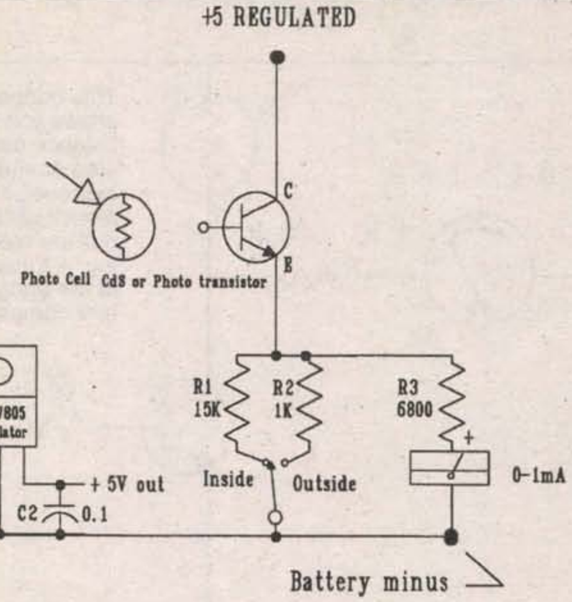
Ambient Light, Digital Display

Most of what I just said applies to the digital version, Figure 8. However, due to the inherent amplification built into the digital panel meter, it is too sensitive for use without some additional scaling. That is what the 82K fixed resistor and the 10K potentiometer do. They take just a small part of the voltage developed at the emitter of the photo transistor, and apply that reduced voltage to the input of the DPM.

With the range switch set for LOW, and in a room with "normal" lighting, a bench meter measured 2.5 volts between the emitter of the photo transistor and the battery minus. The panel meter on the light meter read 1155. Of the 2.5 volts applied to the metering circuit, the meter saw 0.1155 volts. Moving the range switch to the HIGH position caused the voltage to drop to about 3 mV (0.003V). The panel meter showed 001, 0.001 volts or 1 millivolt. On the next least sensitive range (switch set at 4, note Photo

Table below shows suggested values for scaling resistor R3, with common meters.

Simplified drawing of light meter with analog readout. Instead of the photo transistor, a CdS photo cell may be used. One is shown to the left of the photo transistor.



Meter	Resistor
1mA	6800
500uA	12 000
100uA	68 000
50uA	120 000

FIGURE 7.

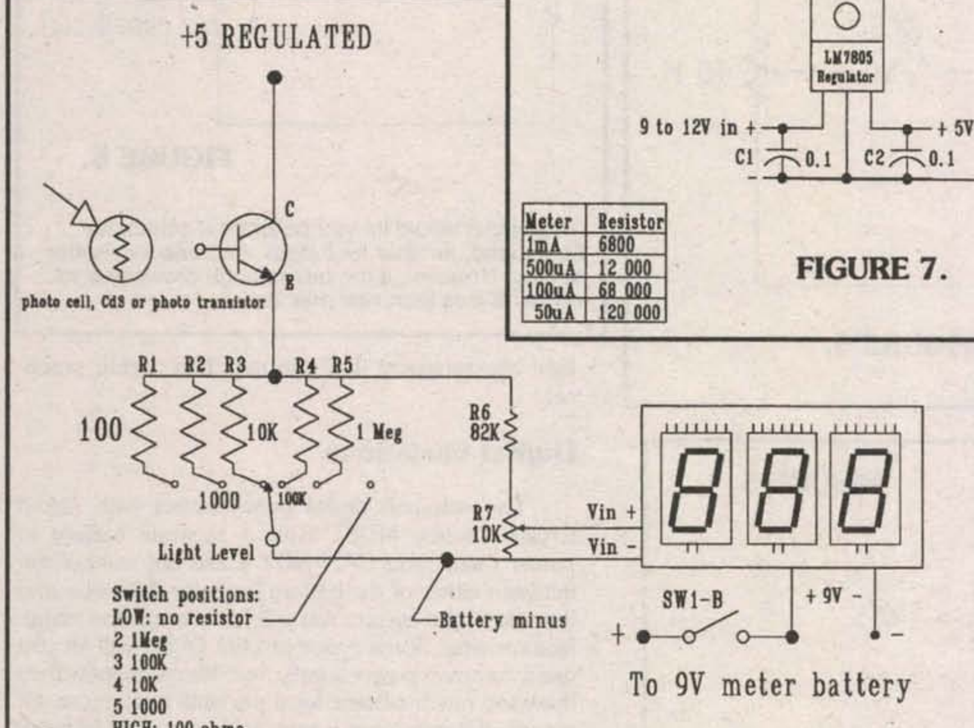


FIGURE 8.

For details of SW1-A and the regulator, see Figure 10.

D) it showed 14. Since we have a six-position switch, we may as well take advantage of it and get several ranges even though the lowest range may or may not have a direct application in photography. Of course, you could work out a chart with exposure values for it.

Although the switch and resistors do cost us a few additional parts, they do buy us something: We get multiple ranges. The highest range lends itself to outside use. The lowest range works best inside a poorly-lit room or for looking at light levels on your TV or monitor screen.

Pictures from Your TV Screen

If you use it to get a measurement of the light from a TV, with the idea of taking a picture, remember, you MUST use a shutter speed of 1/30 of a second or slower and adjust your f stop for the correct exposure. I know how hard it is to get people on TV to hold still long enough to get a good picture.

I have gotten good results, but it took several shots — a luxury that your subject may not always give you.

Nowadays, you may have the option of videotaping the subject and using other methods to get a printed picture.

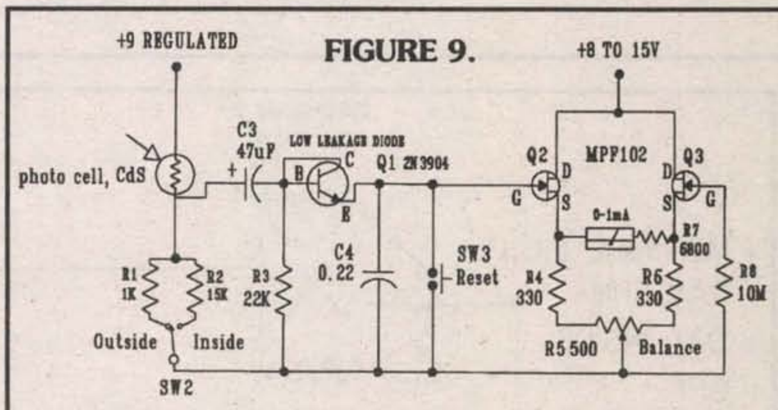
Even if you tape the subject and 'freeze frame' it on your TV, you still have to use a 1/30 or slower shutter speed if you take a picture of the subject on the monitor.

Strobe Light

Electronic flash — usually referred to as strobe light — makes action or low light-level pictures practical. Even in areas that have a moderate amount of ambient or 'available' light, the sudden, short burst of light from the strobe freezes action.

The light from common strobes lasts about 1mS (0.001S); some longer, some shorter. The old, hard-to-find flashbulbs took about 18-20mS (0.018-0.020S) to reach their peak. However, even the smaller flashbulbs put out more light than many of the portable strobes. With fast, short, light bursts we have to use some other means of measuring the light level on the subject.

FIGURE 9.



SW1, ON/OFF, connects the battery to the regulator. C1 and C2 go on the regulator, see Figure 11. Q1, a 2N3904, is connected as a diode. Analog display with CdS sensor will work, but photo transistor gives better results. Typical values shown for working model: Photo C. Using 9V instead of 5V gives a bit more sensitivity. However, this requires a 12V battery; somewhat less inconvenient than a 9V battery. See Figure 11 for details of regulator.

Strobe Level Meters

We can take our time measuring ambient light since it stays turned "on" while we measure it and take a picture. The strobe, though, puts out its light burst in the blink of an eye. In electronic terms, it produces a pulse. Measuring pulses produces its own set of inconveniences. The simple ohmmeter with photo cell would record the light burst as a mere flick of the needle. The digital display would just jump around a bit. We have to separate the available light from the bursts, and we have to 'sample and hold' the signals

that result from the light burst.

Separating the Types of Light

In the light meters we have talked about so far, we had a DC (direct current) connection between the photo detector and the meter. Most of the circuits pass the changes in current or voltage through range or sensitivity adjustments to the readout. DC does not go through a capacitor. After the capacitor charges, unless there is a change in voltage level, the current stops flowing. Figure 9 shows a photo cell with the HIGH/LOW (INSIDE/OUTSIDE) range switch and a capacitor from that point to the rest of the circuit. The capacitor will allow ONLY CHANGES in voltage to pass on to the rest of the circuit. The 22K ohm resistor gives the capacitor and the diode the DC return path that they need.

FIGURE 10.

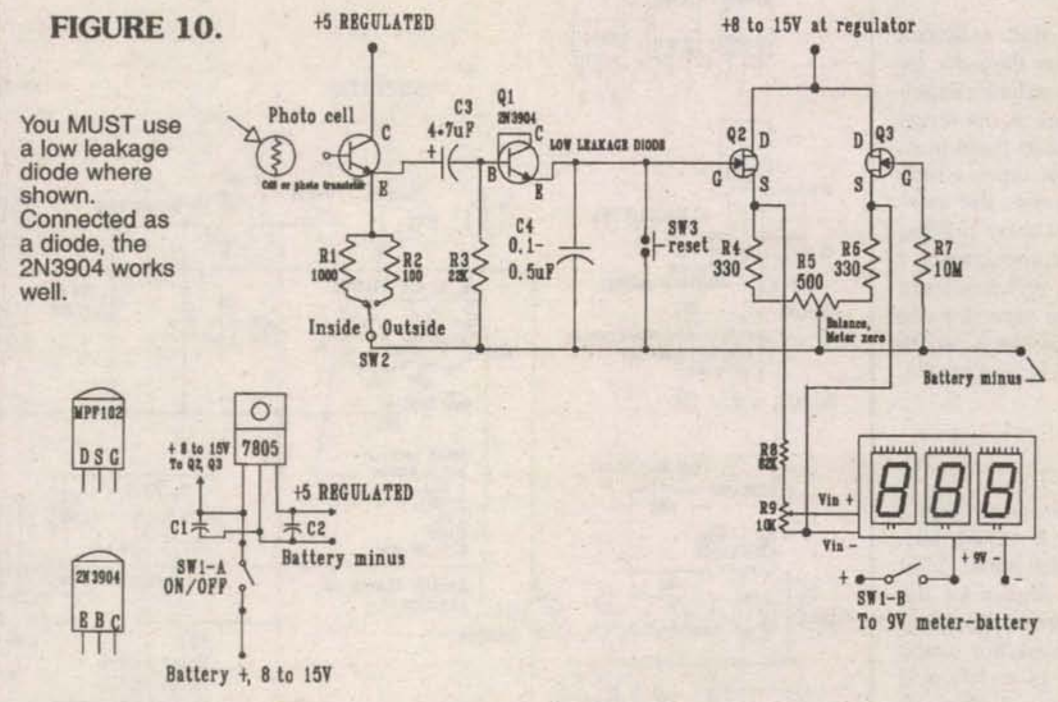
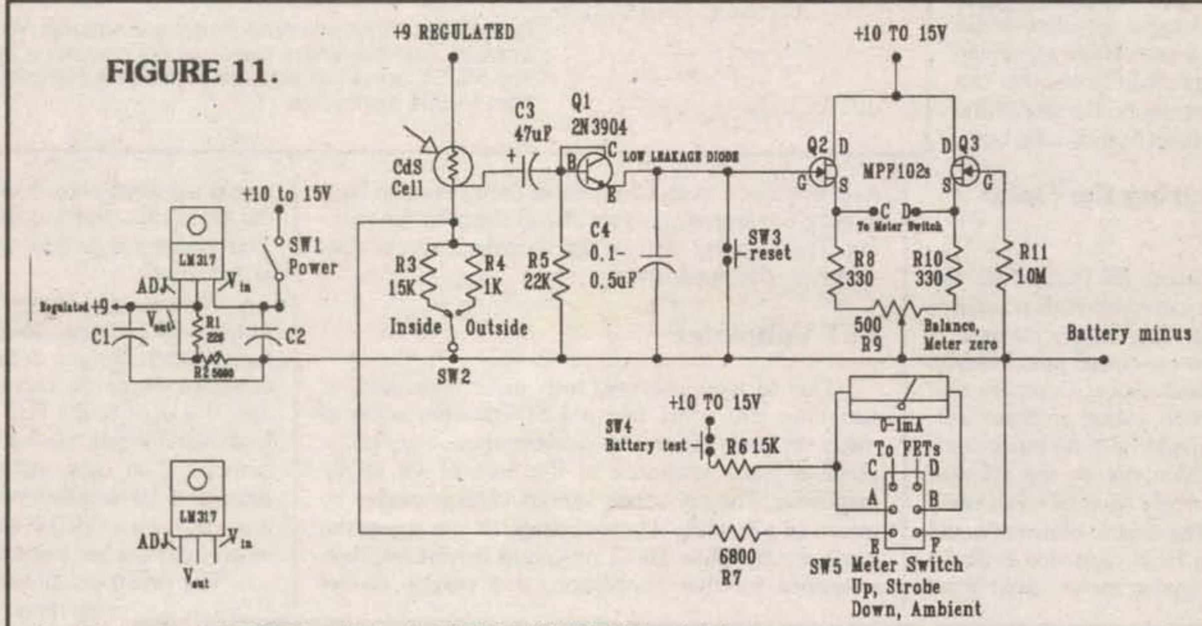


FIGURE 11.



For Battery test: POWER switch off, STROBE/AMBIENT switch in AMBIENT position. Press TEST button, full scale = 15 volts. As an option, you could take the RESET circuit from **Figure 7 (Part 2)** and add it to this circuit.

Sample and Hold Considerations

During the time that the photo detector sees the light burst, its internal resistance drops, putting a relatively large voltage across the range resistor and the coupling capacitor.

The diode allows this voltage burst to get to the 'hold' or integrating capacitor; keeping it there long enough to measure it presents some interesting problems.

The Low Leakage Diode

A diode couples the pulse from the photo cell to the Hold capacitor. Then the diode prevents the circuit that produced the charge from bleeding the charge off of the Hold cap.

While all diodes leak some current in the reverse or normally non-conducting direction, usually that current is so small that we can ignore it.

For example, the common 1N4007 may have as much as one amp flow through it in the forward direction, and only low microamps leak in the reverse direction.

However, I found that the 1N4007 and the popular signal diode — the 1N914 — leaked too much to use in this application. They allowed the charge to leak off of the Hold cap too fast for this application. The Hold capacitor must hang onto its charge long enough for us to read the display.

With an analog display, I could see the needle drop fast enough that I did not bother to reach for a stopwatch. Of course, the digital display 'rattled' around enough to be annoying.

Cheap, Practical Cure

Without going into too much boring detail, I remembered some earlier work with ordinary, cheap, silicon transistors. When it has no base current, the collector-to-emitter circuit of a common small-signal, silicon transistor looks like an extremely large resistance. My indirect measurements indicate that the resistance of the 2N3904 is so high, that it will work as a low leakage diode. The resistance of the gate circuit of the FET meter circuit combined with the resistance of the 2N3904 give an estimated resistance of three to four times 10 to the 11th ohms. That is a 3, or a 4, with a string of 11 zeros after it.

The practical application of this means that it will take 24 hours, or longer, for the voltage in the Hold cap to leak down to about 37% of its initial value; what it read just after you fired your flash at it. That gives you enough time to get a reading before it changes a significant amount.

A good sample and hold circuit should hold longer than that. I can think of a digital circuit that would hold until this time next year, but we want to keep these circuits simple and practical.

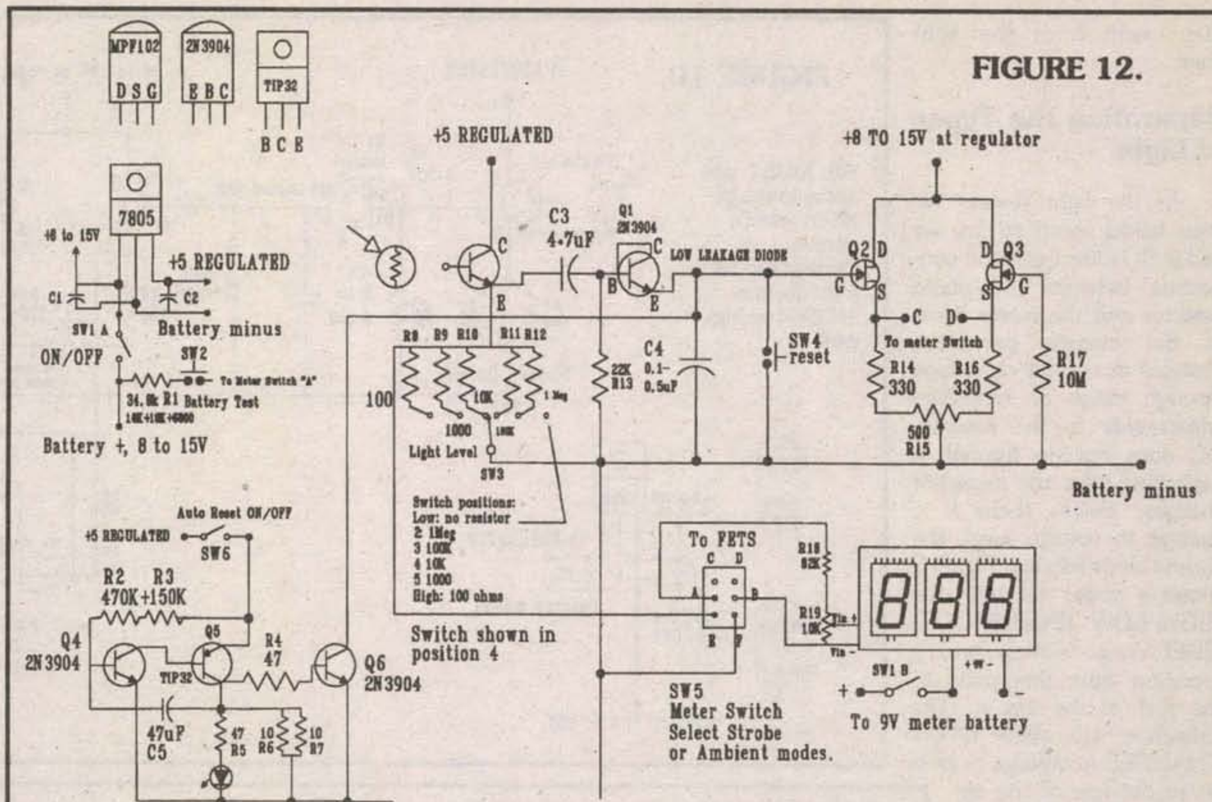
The Hold Capacitor

For some reason, I thought that tantalum capacitors had low leakage. Perhaps they do, by comparison with other types of electrolytic capacitors. However, I found that tantalums in the range of one to 10 uF leaked enough to keep them from use in this circuit. I tried metal-film types which fared little better. Much to my surprise, the inexpensive green polyester caps just sat there holding a charge longer than I could hold my breath. I reached for the stopwatch, started it, and then went to work. When I got home, the Hold capacitor still had an appreciable charge. It looked like a practical, sample and hold circuit; not perfect, just simple, economical, and practical.

Sizing the Capacitor

A large capacitor would hold the charge longer than a small capacitor, however, it would take longer to charge it during the light burst. That would give a lower reading on the display for the same size light burst. That would amount to a less sensitive instrument. Too small a capacitor would not pick up all of the charge sent to it. It would reach its highest voltage level and stop charging. It would saturate. That would give inaccurate indications of the light level. Too large a capacitor would give lower readings. To get a reasonable sensitivity and get measurements of high light levels, you can adjust the size of the range resistors, the size of the capacitor, or both. In these instruments, I did both.

FIGURE 12.



Both Battery Test and Auto Reset are optional. You may make just the ambient, just the strobe meter, or the combined system as shown here. You MUST use a low leakage diode where shown. Connected as shown, the 2N3904 works well.

Voltmeters for Measuring the Hold Capacitor

The Field Effect Transistors (FET) used for the metering circuit presents an extremely high resistance to the circuit under test. The Gate-Source circuit of a junction FET looks like a reverse-biased junction with the estimated resistance noted above. Compare that to the resistance of your bench analog or digital voltmeters. The analog meter might have an input resistance in the area of 50,000 ohms on the 2.5 volt scale. The digital voltmeter might have an input resistance of 11 million ohms. The digital voltmeter would bleed the charge off of the Hold capacitor in about two to three seconds. The analog meter would bleed it off in about a tenth of a second; hardly enough time to get a reading using either one of them for the readout. That explains why we had to make a special voltmeter for this application.

FET Voltmeter

Due to their relatively high input resistance, at one time you could find a FET volt-ohm-milliamp meter on many electronics workbenches. They had a nominal input resistance in the area of 10 to 11 megohms. They got their various voltage ranges by means of a carefully selected voltage divider across the input circuit. While 10-11 megohms is relatively high resistance for that application, that voltage divider would not work here. It would bleed the charge off of the Hold capacitor too fast for you to get a reading. This circuit has to have as high an input impedance as practical.

The circuit in Figure 9 shows the first FET going to the Low Leakage diode, the Hold capacitor, and a Reset switch. Sooner or later you do want to reset the capacitor. Since the capacitor resists changes in voltage, the input to the FET voltmeter will hold relatively still until it gets a pulse from the light via the photo detector. The other gate returns to battery minus through a 10-megohm resistor. In some applications, it would have a 0.01uF capacitor across it. I left it off when I did not see instability in the meter.

The drains go directly to the battery plus which may range from 8-15 volts. If you stay within that range, you do not need a regulator for the drain voltage. I use this basic voltmeter circuit to read and to control the high voltage in my portable strobes. They hold the high voltage to within 5 volts in 450 volts. I built them before I ever heard of a 7805.

The sources return to battery minus through 330-ohm resistors and the voltmeter balance control. The diagram calls for a 500-ohm control. The photo shows a 2,200-ohm control. I had to use what I could get without chasing all over for it. The smaller pot would give better resolution when setting the zero or balance. However, even with the 2,200 ohm pot, despite the more than two-to-one increase in resistance, the adjustment is not too critical.

The display, either A or D, connects to the junction of the source and the 330-ohm resistors. In essence, the FETs and the resistors form a bridge circuit. With zero voltage on the capacitor, the 500-ohm balance control is adjusted for a zero reading on the display. When a voltage is applied to either gate, that upsets the initial balance causing the meter to respond. Putting a voltage on one gate will cause the analog meter to deflect in one direction. Putting the voltage on

the other gate will cause the meter to deflect in the other direction. A digital readout would show a voltage with either a plus or a minus sign.

The meters that I made show good stability; more than adequate for the intended purpose. Joe W. at Tempe Camera, let me compare one of his rental strobe-light meters with mine. His will read ambient light and give suggested camera settings. The LCD display gives direct readout in tenths of an f stop, has auto reset, uses a microprocessor, and starts at $125.00, or a reasonable daily rental. That works for the professional photographer, but for a weekend tinkerer, I will go with these and make up a calibration chart.

TABLE 1. SETTINGS FOR ASA 200-250

Meter Readings Indoors (analog meter)	Shutter Speed (seconds)	f Stop (suggested) lens setting)
2-3 Average Room Lighting	1/60	1.8
	1/30	2.8
	1/15	4
	1/8	5.6
	1/4	8
	1/2	11
	1	16
	2	22
6-7 Well-Lit Room	1/1000	2
	1/500	4
	1/250	5.6
	1/125	8
	1/60	11
	1/30	16
	1/15	22

Remember, these are only suggested values. You will come up with a similar table.

Which One?

If you seldom use strobe, or seldom use available light, you may wish to make only the applicable unit just described. However, if you want to do both, decide on analog or digital readout and look at one of the diagrams of the complete system.

Analog

The complete analog system (Figure 11) uses a 12-volt power source to give the sensitivity a slight boost. It uses an LM317 adjustable regulator to get the regulated nine volts for the photo cell, in this case a CdS cell. You may use a photo transistor here if you wish. These light meters have more options than something that you would find in the stock market. You can add the Auto-Reset feature to this unit by picking the parts off of the digital system diagram, Figure 12 or from Figure 13 — the reset circuit itself.

Battery Test

It seemed a shame to have to take the unit apart just to check the battery, especially when it has a built-in voltmeter. In the analog unit, the meter came from RadioShack with a 15,000-ohm resistor, that would give the meter a full scale deflection of 15 volts. However, it has a catch: finding a way to check the battery without upsetting the other functions. I refuse to design something like this with an impossible to find switch or, for that matter, any other hard-to-find part. That results in a bit of a compromise in that measurement.

To test the battery, you have to turn off the power, set the STROBE/AMBIENT switch to the AMBIENT position, and push the BATTERY TEST button. While this gives a no load battery test, it does give a reasonable indication of the state of the battery. If the battery shows under 10 volts without a load, then it will have a bit lower voltage while powering the meter. Much below 10 volts, the regulator will put out less than nine volts.

For practical considerations, a dry cell is considered to have 'run down' if it shows less than 20% of its new terminal voltage. In this case, that would be 9.6 volts for a 12-volt battery. Since someone finally came out with a holder for "AAA" batteries, you have a good way to get 12-15 volts into a reasonable size instrument.

Digital Battery Test

Testing the battery in the analog version was a bit unconventional, but the battery test in the digital version gets rather crude. It keeps the wiring simple at the expense of switch settings. They are as follows: RANGE switch to "4;" STROBE/AMBIENT switch to AMBIENT; POWER switch ON, shield the photo cell from light; press the BATT TEST button. You get direct readout in volts.

While I can live with that procedure for an occasional battery test, you may find all of that a bit much, so you could leave off the battery test, or use a DPDT test switch and run the metering circuit through it. You would also have to put in a voltage divider which would bleed a small current out of the battery anytime that the unit is on, not just when you want to test the battery. The battery for the main circuit will run down before the battery that powers the readout.

Size vs. Other Considerations

The commercial, shirt-pocket-sized meter mentioned a while ago uses a handful of "button" cells. I do not know what kind of regulators it uses — if any — nor how much difficulty you would have finding the button batteries. The "AA," "AAA," and the nine-volt batteries have become common enough that I will make a slightly (?) larger instrument knowing that I can find the batteries for it. Super small at a price works for the commercial photographer. On my budget, and with the uses that I have for the light meters, I will have to settle for slightly larger.

Digital

The complete digital system (Figure 12) combines all of the features that you might want, and then some. You have the option of five ranges for ambient light and two ranges for strobe, as well as manual or auto-reset for the strobe light measurements; a winking LED; battery test; and, of course, digital readout. The digital readout gives higher resolution and some built-in amplification for greater sensitivity.

The winking LED lets you know that the auto-reset circuit fired a pulse into the reset transistor dumping the charge on the Hold capacitor, resetting it back to zero. A quick glance at the display would tell you the same thing, but if you catch the light, that lets you know how soon to expect the next reset pulse. Sometimes you want that on auto and sometimes you want to do it yourself.

While testing the commercial unit from Tempe Camera, sometimes I found the auto-reset at one time per minute came too often. Other times it was not often enough. You could add just one resistor and a switch to the reset circuit, Figure 12 or 13, and get two reset times.

For some applications, once every 10 seconds might work. For other uses, once every minute or two would be better. If you are going to make your own, make it do what best suits your needs. If this is one of your first projects, you might find one of the complete systems somewhat overwhelming, which explains why I broke it into smaller pieces. Next month, we will get started on construction going into specific details that apply to a particular system. **NV**

A complete parts list will be included in Part 2.

AMATEUR ROBOTICS NOTEBOOK

by Robert Nansel

Last month, we started our first PIC assembly language project for Breadbot. We only got as far as reading the status of a switch, and turning an LED ON or OFF in response. But, for a home-built microcontroller, that's all we need to ensure that the basic hardware core of the system is working.

This month, we'll finish the brain transplant, and we'll push the software much farther, to a complete working robot control program that implements a rudimentary "wander" behavior for Breadbot.

This is the first program presented in the Breadbot series that makes full use of the bumper and whisker contact sensors and, while it's a long way away from the sophistication of a Lumelsky Bug (see my January '99 *Nuts*

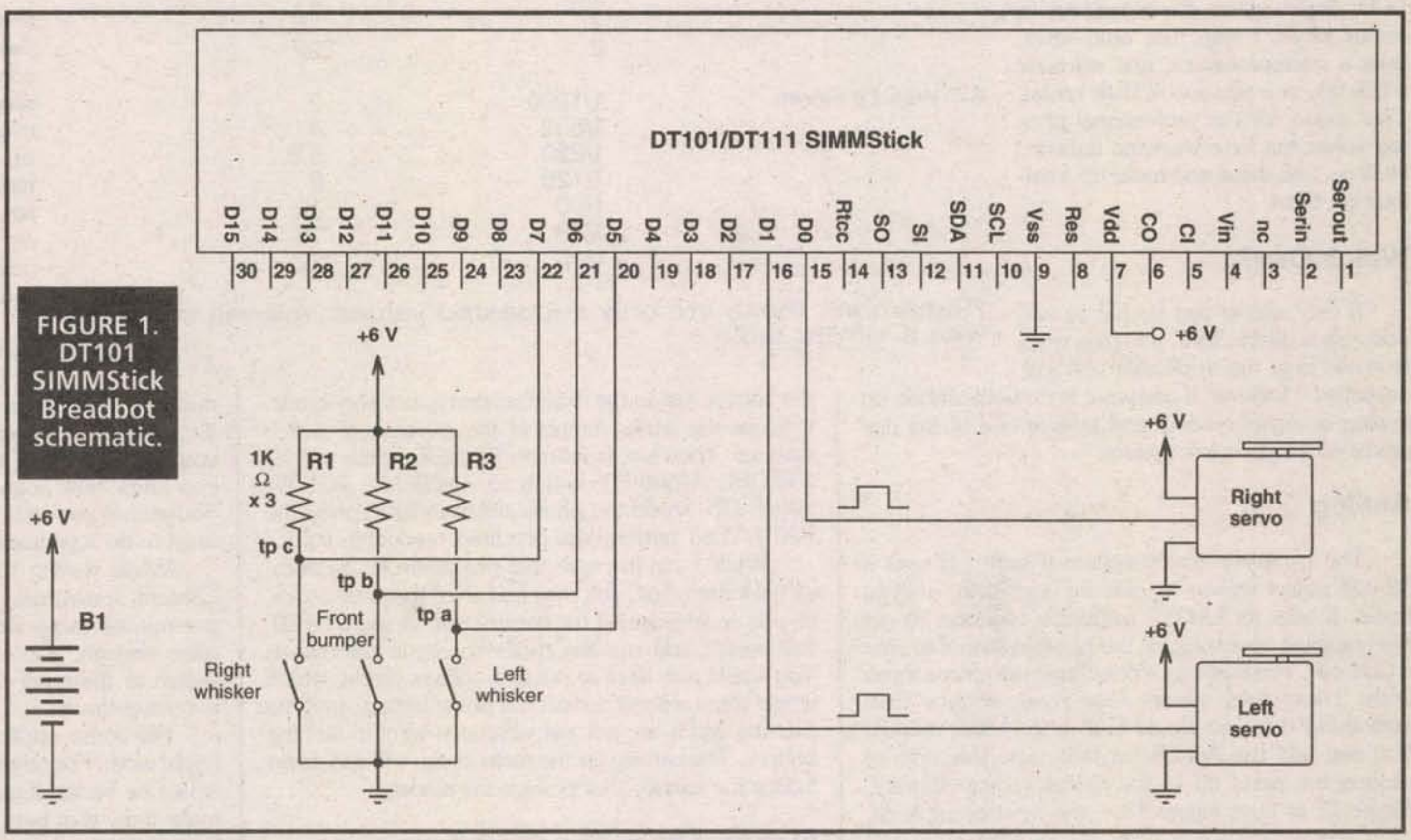


FIGURE 1. DT101 SIMMStick Breadbot schematic.

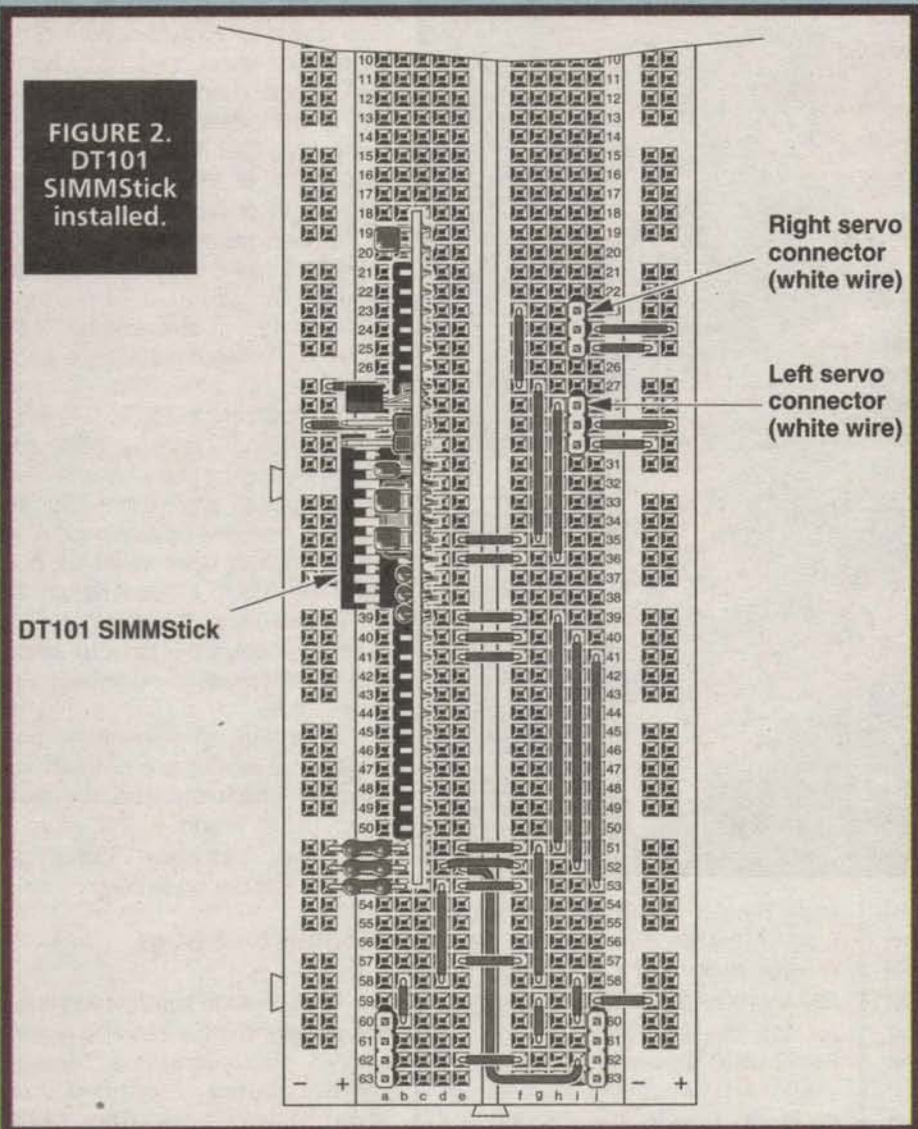


FIGURE 2. DT101 SIMMStick installed.

& Volts column), it does surprisingly well at wandering around my kitchen without getting stuck.

I also promised a few surprises this month, two new arrivals that I'm just busting to show off. I wasn't sure whether either would be ready in time for this column, but I'm pleased to say that both arrived in time (barely).

Project Yonatan

The first arrival came on January 25, 1999, marking the end of the beginning phase of my longest term project ever. On that date at 9:27 pm, after 18 hard hours of labor – including three and a half hours of determined pushing – my wife Shoshana gave birth to our son Yonatan Yosef Nansel, all nine pounds of him.

Now, Shoshana only weighed 105 to begin with before we started the Yonatan project, so you can imagine the magnitude of her accomplishment. I'm certainly in awe of it, and when I think of all the billions of other babies that have come into this world in a similar way, well, it makes me – a 220-lb. hulkish male – feel downright humble.

So, I'm not getting much sleep. And I don't have quite as much time to build robots as I once enjoyed. But I do have a wonderful example of emergent intelligence right before me as I look into my son's eyes.

The other arrival came a few days later – a shipment of two Parallax GrowBot kits, complete with extra Bread Board and Proto Board AppModules expansion modules. Normally this would have been a big day here at the Robot Ranch, but Yonatan severely upstaged the arrival of the GrowBot kits. I didn't even get around to opening the kits for a couple days, and then it took another couple days – in between feedings and diaper changes — for me to put one of the kits together.

As of this writing, I haven't had time enough to put the bot through a thorough shakedown, but I did snap a few pictures, and I have some preliminary comments later in this column. But, before I get into that, I want to talk about the thing I've been promising y'all for months: a new brain for BreadBot.

One Brain Coming Up

Last month, I told you how to build the DonTronics DT101 SIMMStick and how to do the preliminary hardware debugging. This month, we'll install the new brain and program it. Figures 1 and 2 show the schematic and wiring diagrams for the DT101/Breadbot combination. If you've built any of the previous Breadbot versions, it's a snap to put this one together.

If you are starting from scratch, I recommend you look up at least the first two Breadbot articles that appeared in the June and July '98 issues of *Nuts & Volts*. With those first two articles and last month's article in hand, you will have all the information you need to build your own Breadbot.

The real thing that separates this Breadbot brain from all the other Breadbot projects is the software, and that's what I want to concentrate on now.

The program listing WANDER.ASM can be divided into four major parts: the declarations, the Interrupt Service Routine (ISR), the Main control loop, and the subroutines called by the ISR and the Main control loop.

Other than the comments, everything before the CBLOCK of the declarations is identical to last month's listing. It tells the assembler that we're using a PIC16F84 chip, that we want an eight-bit Intel Hex output file, and that we want to use decimal numbers. It also sets up which types of error messages will be displayed during assembly, and it includes the standard equates and register names for the PIC16F84.

The CBLOCK statement allocates RAM for program variables starting at RAM location 0x00C; using CBLOCK means we don't have to worry about exactly where each of these variables are located. We only need to reference them by name elsewhere in the program.

After CBLOCK comes the I/O bit constants. These are just the bit position numbers of the various input and output bits used by Breadbot. By changing bit numbers here and referencing those I/O bits by name elsewhere (i.e., using the name "RWhisk" instead of the numerical constant "7" it equals), you can change which I/O function is allocated to which bit without having to change it everywhere you use that bit in the program.

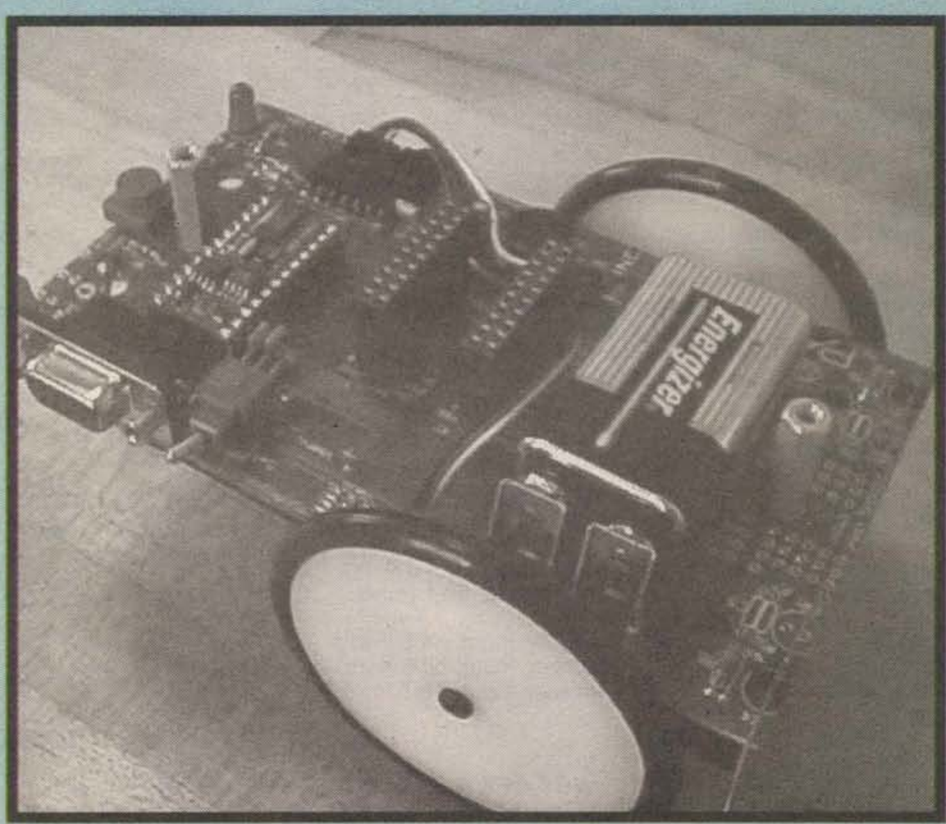
Finally, after declaring the I/O bits, it sets up the configuration bits for the F84; in this case, the F84 is configured with the Code Protect OFF, the watchdog timer disabled, the oscillator option set up for a high speed crystal or resonator, and the power-up timer enabled.

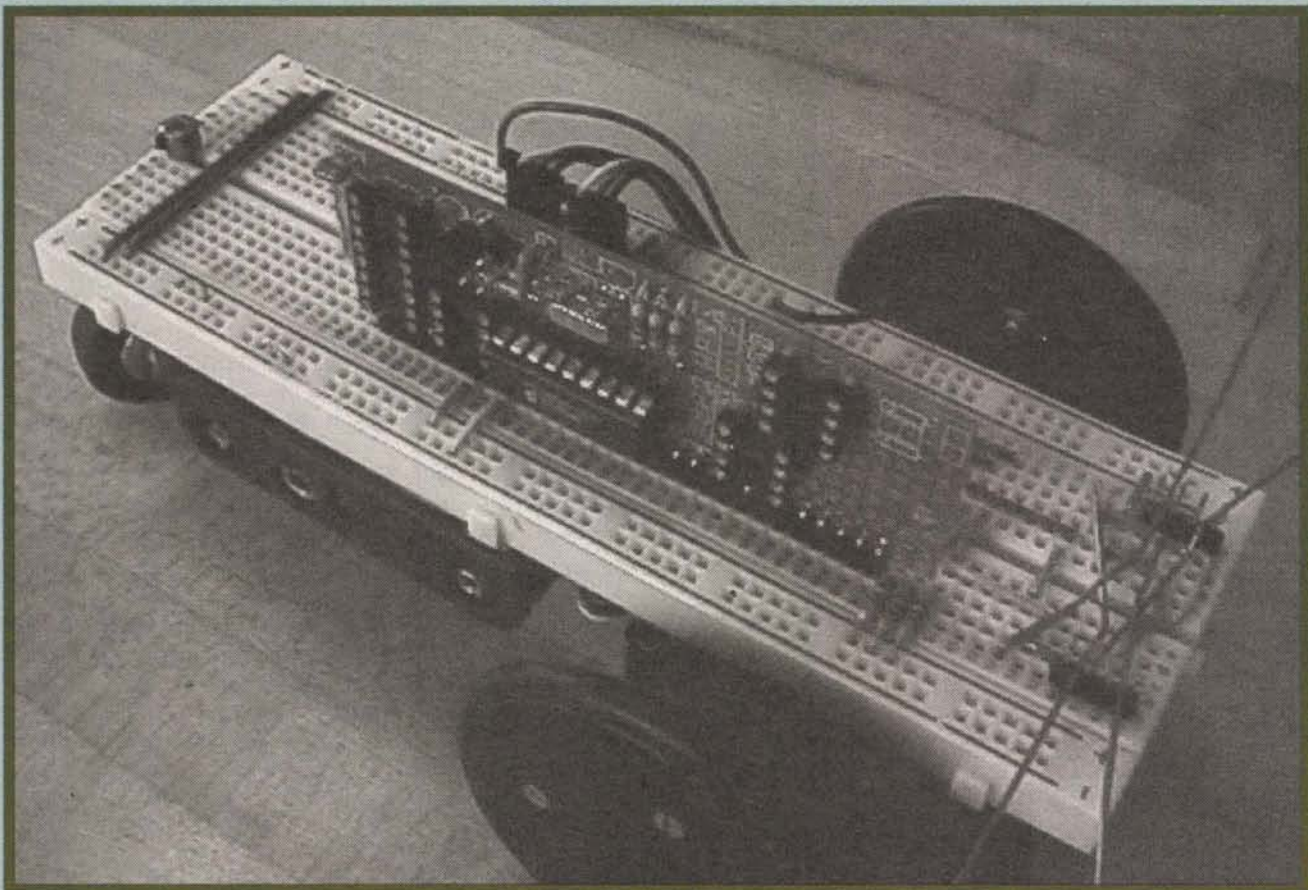
The F84 begins execution on reset at program memory location zero. Since the ISR must begin at location four, a GOTO instruction must be placed at location zero to jump over the ISR to the main program.

Interruptions

The second major section is the Interrupt Service Routine. The first thing the ISR does is save the Status and the W registers (the "Context) so that those values can later be restored before returning from the ISR to the interrupted code. Since the ISR is designed to be executed every 20 msec or 50 Hz, the ISR then resets the interrupt from TMR0 to occur again in 20 msec; a count of 61 on TMR0 as configured.

The ISR then performs two main functions: First, it increments the RAM variable RTC to update the Real Time Clock. Second, it generates two simultaneous variable-width pulses on LPulse and RPulse which are connected to the left and right servos, respectively. Servos require





positive going pulses ranging from one to two msec long, with 1.5 msec being neutral or stop.

ISR accomplishes this by first setting both pulse outputs high for one msec by cycling through the loop Msec 250 times, expending a total of 2500 processor cycles. It then executes Intloop, which compares the loop counter Msec_Cnt (also used in the Msec loop above) with the time out values "left" and "right" for both pulses, resetting each pulse at the appointed time and terminating after one msec.

This is the basic strategy that Myke Predko uses to drive servos in one of the programs in his book *Programming and Customizing the PIC Microcontroller*, but I adapted it for the 10 MHz clock rate of the F84. I also "unrolled" the loop part way so that two checks are made for each servo each time through the loop. This allowed me to get the loop down to 20 cycles, nine cycles for the first check, and 11 cycles for the second check, which averages out to 10 cycles per check. Doing this gives a four microsecond resolution which, in turn, allows the variable-length pulses to be controlled by numbers ranging from 0 to 250.

A 1.5 msec pulse on LPulse, for example, is generated by placing a value of 125 in the variable "left." Since the timeout values are being compared to Msec_Cnt — which counts down from 250 to 0 — left = 0 generates a 2.0 msec pulse (the one msec fixed pulse plus one msec variable pulse), while left = 250 generates a one msec pulse (one msec fixed plus zero msec variable). Both "left" and "right" timeout values are set in the main control loop. The main loop writes the timeout values, and the ISR reads but does not alter those values.

After Intloop terminates, both LPulse and RPulse are brought low to make absolutely sure the maximum pulse length is 2.0 msec in case they somehow don't get brought low during Intloop.

Scoping Out Bugs

Next, though commented out in this version, the ISR can also make a call to the subroutine "debug," another routine I adapted from Myke Predko's book. This routine

```
        title "WANDER.ASM - Robot wander behavior test"
;
;
;  DT101 Breadbot wander program, 2/1/99, Robert Nansel
;
; After initialization, Breadbot moves forward until an obstacle is detected.
; A right whisker touch causes Breadbot to back, turn left, then resume forward
; motion, a left whisker touch triggers a backup then a right turn, and a front
; bumper touch triggers a backup then a random left or right turn.
;
; NOTE: Debug sections commented out in this version
;
;

        LIST P=16F84, F=INHX8M, R=DEC          ; 16F84 Runs at 10 MHz
        errorlevel 0,-305
        INCLUDE "\pic\mpasm\p16F84.inc"

; RAM Usage

        CBLOCK 0x00C
_w              ; Interrupt Service Routine Context Saving Values
_status
left, right; Servos speeds
RTC             ; Real Time clock, 20 msec resolution
Msec_Cnt        ; Millisecond delay counter
delay_count     ; 20 msec resolution delay counter
debug_buf       ; debug byte buffer
bit_count       ; bit shift counter
temp            ; temporary storage
        ENDC

; I/O bit Constants

SCL     equ     0       ; Serial Clock, output, bit 0 PortA
SDA     equ     1       ; Serial Data, output, bit 1 PortA

RPulse  equ     0       ; Right servo, output, bit 0 PortB
LPulse  equ     1       ; Left servo, output, bit 1 PortB

LWhisk  equ     5       ; Right whisker, input, bit 5 PortB
FBump   equ     6       ; Front bumper, input, bit 6 PortB
RWhisk  equ     7       ; Right whisker, input, bit 7 PortB

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        __CONFIG _CP_OFF & _WDT_OFF & _HS_OSC & _PWRTE_ON
; Note: WatchDog Timer is OFF
```

```
; Code for WANDER

        org     0

        goto    Main                    ; Skip Over Interrupt Service
Routine

; Interrupt Service Routine - Output proper speeds to servos

        org     4                       ; ISR at Address 4

Int
        movwf   _w                      ; Save the Context Registers
        movf    STATUS, w
        movwf   _status

        movlw   61                      ; Wait 20 msec between operations
        movwf   TMR0

        movlw   0x020                   ; Reset the Interrupt Handler
        movwf   INTCON

        incf    RTC                     ; Update Real Time Clock

        bsf     PORTB, RPulse           ; Start both servo pulses
        bsf     PORTB, LPulse

        movlw   250                     ; Delay 1 msec before doing
                                        ; variable
        movwf   Msec_Cnt                ; part of pulses
Msec    goto    $ + 1                   ; 10 Cycle loop delay -> 2500
cycles
        goto    $ + 1
        goto    $ + 1
        nop
        decfsz  Msec_Cnt
        goto    Msec

        movlw   250                     ; Set up to time second msec
        movwf   Msec_Cnt                ;  —> must be an even number <—
Intloop                                 ; 20 cycle loop, 19 on termination
                                        ; average 10 cycles per pulse check

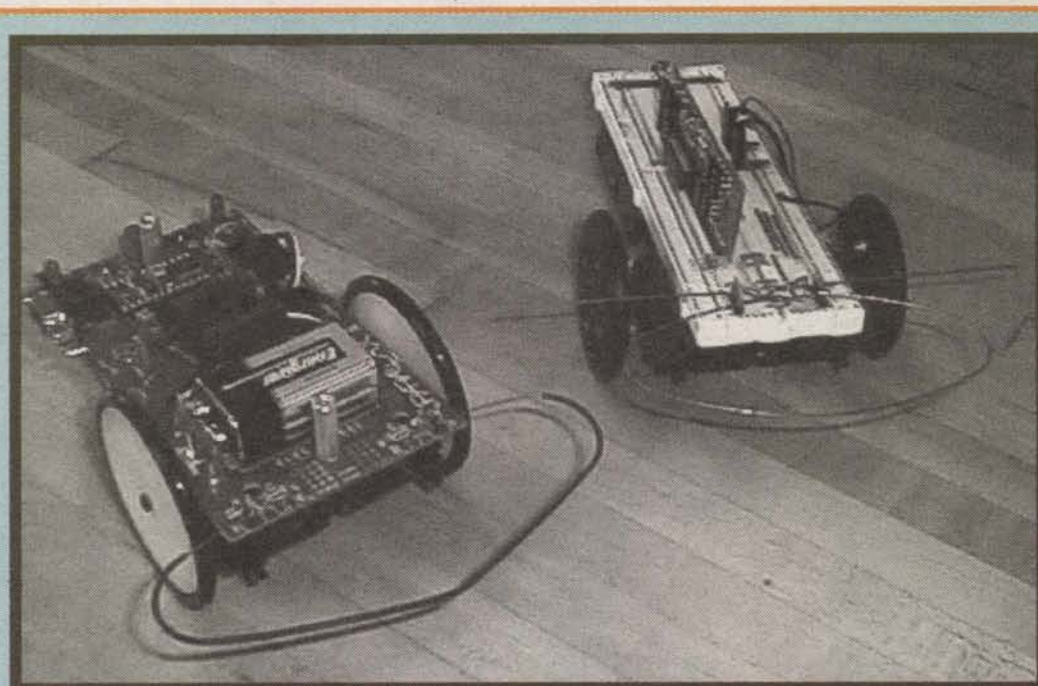
        movf    Msec_Cnt, w             ; Check right servo
```

shifts out the eight-bit value contained in debug_buf. The data is shifted out on SDA, SS-Bus pin 11, and a clock pulse for each bit is sent separately on SCL, SS-Bus pin 10. You can use these signals to directly drive a serial to parallel shift register to display the data with eight LEDs.

Or you can do what I did: display these signals on a dual trace oscilloscope. Since the ISR executes at 50 Hz, it's easy to get a stable display when you trigger the scope from the SCL line. The negative-going pulses on SCL mark each data bit on SDA and, in this way, you can read off the binary value directly from the scope's CRT.

Elsewhere in the program you'll see places – again, all commented out in this version – where I load a constant into the W register then save it to debug_buf. I simply assigned a unique identifier number to each logical path of the main control loop.

This was invaluable to me when I was debugging, because by reading that ID number from my scope, I could tell what path was executing at any moment. To make the ID codes easier to read, I temporarily increased delay_count by a factor of eight so the subroutine "delay" would delay eight times longer than normal. Instead of a quarter second to read each ID, this gave me two seconds, which worked fine.



If you want to make changes to WANDER.ASM, you might consider uncommenting the call to debug in the ISR and the debug assignments in Main by removing the semicolons that make those lines into comments. That way you'll have a powerful debugging tool available. With minor changes to the debug code, you can also output more than one number. A particularly useful variation outputs the value of the W register followed by an ID code as before. This gives you most of the power of an emulator with none of the cost (save a few lines of code).

I'll talk more about this and similar techniques in future columns. The ISR finishes by restoring the W and STATUS registers.

The Main Thing

The first section of Main sets up the interrupt clock source, config-

```
        subwf   right, w            ;
        btfsc   STATUS, C           ; If right <= Count then more time left
        bcf     PORTB, RPulse       ; Else, end right pulse

        movf    Msec_Cnt, w         ; Check left servo
        subwf   left, w
        btfsc   STATUS, C           ; If left <= Count  then more time left
        bcf     PORTB, LPulse       ; Else, end left pulse

        decf    Msec_Cnt            ; Note: won't = 0 if Msec_Cnt is even
                                    ; on loop entry

        movf    Msec_Cnt, w         ; Check right servo
        subwf   right, w            ;
        btfsc   STATUS, C           ; If right <= Count then more time left
        bcf     PORTB, RPulse       ; Else, end right pulse

        movf    Msec_Cnt, w         ; Check left servo
        subwf   left, w
        btfsc   STATUS, C           ; If left <= Count  then more time left
        bcf     PORTB, LPulse       ; Else, end left pulse

        decfsz  Msec_Cnt            ; Continue millisecond countdown
        goto    Intloop

        bcf     PORTB, RPulse  ; Make sure both servo pulses turn off
        bcf     PORTB, LPulse
        andwf   PORTB

;       call    debug               ; Shift out debug value, msb first

IntEnd                              ; Finished with the Interrupt

        movf    _status, w
        movwf   STATUS
        swapf   _w
        swapf   _w, w

        retfie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Main
        bsf     STATUS, RP0
        movlw   0x0D7               ; Setup Timer to clock from Internal
                                    ; Clock
        movwf   OPTION_REG & 0x07F  ;  at slowest

        bcf     TRISA & 0x07F, SCL  ; RA0, output, Serial Clock
        bcf     TRISA & 0x07F, SDA  ; RA1, output, Serial Data

        bcf     TRISB & 0x07F, RPulse   ; RB0 is Output (Right)
        bcf     TRISB & 0x07F, LPulse   ; RB1 is Output (Left)
        bcf     STATUS, RP0

        movlw   61                  ;  Set up the Timer - wait 20 msec
        movwf   TMR0

; Initialize Real Time Clock

        clrf    RTC

; Set servo pulses to neutral

        movlw   125                 ; right pulse width = 1.5 msec
        call    set_right_pulse
        movlw   125                 ; left pulse width = 1.5 msec
        call    set_left_pulse

;       movlw   1
;       movwf   debug_buf

; Start interrupts

        movlw   0x0A0               ; Set up Interrupt to run from TMR0
        movwf   INTCON

; Press Front bumper to start motion

wait_bump
        btfsc   PORTB, FBump
        goto wait_bump

;       movlw   2
;       movwf   debug_buf

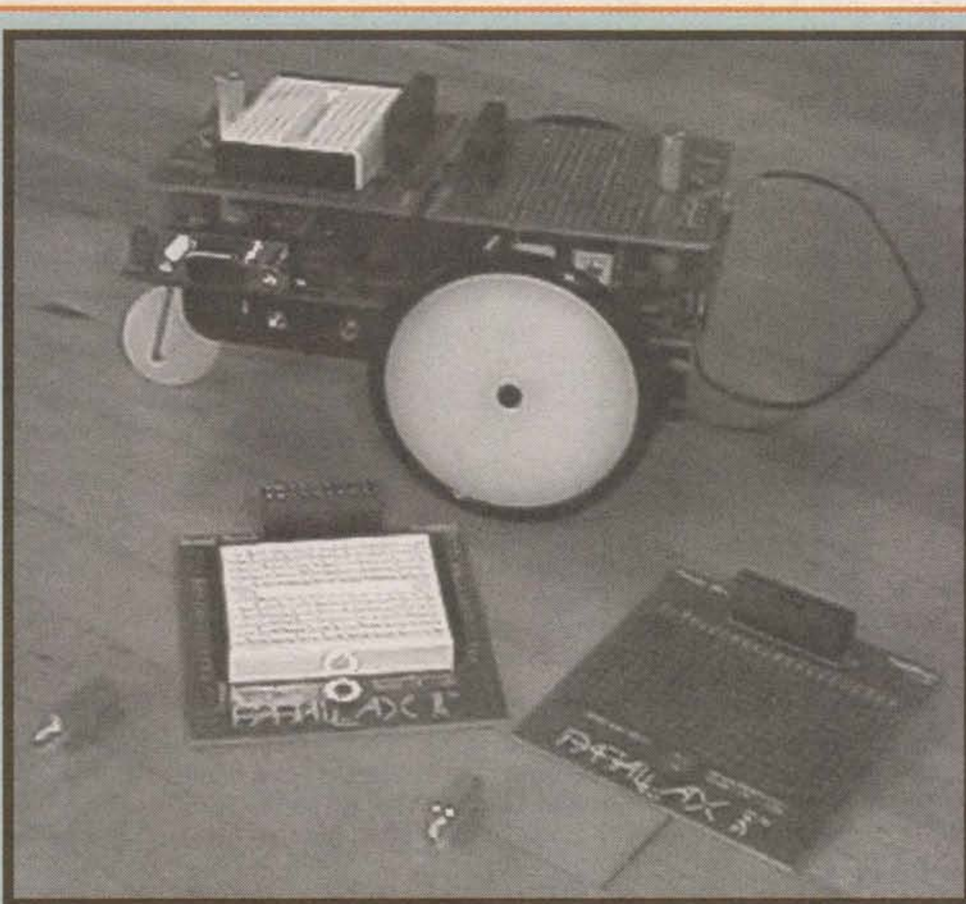
        movlw   12
        call    delay

; Set servo speeds & directions according to state bumper switches
; -> "forward" is default direction of motion

wait_bump2
;       movlw   9
;       movwf   debug_buf

        btfss   PORTB, FBump        ; Check whisker & bumper switches
        goto    front_bump
        btfss   PORTB, RWhisk
        goto    right_bump
        btfss   PORTB, LWhisk
        goto    left_bump

forward
        movlw   0                   ; right pulse width = 1.00 msec
        call    set_right_pulse
        movlw   250                 ; left pulse width = 2.00 msec
```



ures RA0, RA1, RB0, and RB1 as outputs, and sets the timer interrupt to occur in 20 msec.

After zeroing the software Real Time Clock and setting both servo pulse widths to 1.5 msec, Main starts the interrupts running. Thereafter, all changes to the variables "right" and "left" will be reflected by corresponding changes in output pulse lengths.

If you have uncommented the debug call in the ISR, then whatever is in debug_buf will be squirted out SDA and SCL every 20 msec.

The next section of Main simply loops at "wait_bump" until the front bumper is pressed. After a quarter second delay, the program moves on to "wait_bump2," the heart of the wander behavior logic.

The code immediately following "wait_bump2" forms a simple dispatcher that executes the code front_bump, right_bump, or left_bump if any of the bumpers are touched, defaulting to forward motion. Breadbot will thus move forward until an obstacle is detected.

A right whisker touch causes Breadbot to back up, turn left, then resume forward motion; a left whisker touch triggers a back up then a right turn; and a front bumper touch triggers a back up followed by a random left or right turn.

The order of the bumper sensor tests determines the priority of each sensor: The front bumper has the highest priority and overrides both whisker sensors, right whisker has the next highest priority, and the left whisker has the lowest priority. Simply changing the order of these tests changes their relative priority and will affect Breadbot's behavior, a simple experiment from which you can learn a lot.

All of the bumper behaviors invoke the subroutines "backup" and

```
        call    set_left_pulse
        goto    wait_bump2

front_bump
;       movlw   3
;       movwf   debug_buf
        call    backup
        btfss   RTC, 0              ; Use RTC as random coin flip:
        goto    goleft              ; If RTC is even, do left turn
        call    turnright           ; else, do right turn
        goto    forward
goleft  call    turnleft
        goto    forward

right_bump
;       movlw   4
;       movwf   debug_buf
        call    backup
        call    turnleft
        goto    forward

left_bump
;       movlw   5
;       movwf   debug_buf
        call    backup
        call    turnright
        goto    forward

turnright
;       movlw   6
;       movwf   debug_buf
        movlw   250                 ; right pulse width = 2.00 msec
        call    set_right_pulse
        movlw   250                 ; left pulse width = 2.00 msec
        call    set_left_pulse
        movlw   12
        call    delay
        return

turnleft
;       movlw   7
;       movwf   debug_buf
        movlw   0                   ; right pulse width = 1.00 msec
        call    set_right_pulse
        movlw   0                   ; left pulse width = 1.00 msec
        call    set_left_pulse
        movlw   12
        call    delay
        return

backup
;       movlw   8
;       movwf   debug_buf
        movlw   250                 ; right pulse width = 2.00 msec
        call    set_right_pulse
        movlw   0                   ; left pulse width = 1.00 msec
        call    set_left_pulse
        movlw   12
        call    delay
        return

set_right_pulse
        sublw   250                 ; Convert to Msec_Cnt countdown
format
        btfss   STATUS, C           ; Is right pulse > 250 ?
        movlw   250                 ; yes, limit to 250
        movwf   right               ; Set the pulse countdown
        return

set_left_pulse
        sublw   250                 ; Convert to Msec_Cnt countdown
format
        btfss   STATUS, C           ; Is left pulse > 250 ?
        movlw   250                 ; yes, limit to 250
        movwf   left                ; Set the pulse countdown
        return

;
; — Delay - delays "w" 20 msec ticks
;
delay
        addwf   RTC, w              ; Delay w * 20 msec
        movwf   delay_count
d1      movf    RTC, w
        subwf   delay_count, w
        btfsc   STATUS, Z           ; RTC = delay count?
        return                      ; yes, delay is done
        goto    d1                  ; no, continue delay

;
; — Debug routine - 2-wire synchronous serial output of data in debug_buf
;
debug
        movf    debug_buf, w        ; Shift debug_buf out to shift
                                    ; register
        movwf   temp
        movlw   8                   ; # of bits to shift
        movwf   bit_count
Shift_out
        rlf     temp                ; Shift msb into C
        btfsc   STATUS, C           ; If bit set
        goto    Set_bit             ; Then set SDA bit
Clr_bit
        bcf     PORTA, SDA          ; Else clear SDA data bit
        goto    Clock_out
Set_bit
        bsf     PORTA, SDA
Clock_out                           ; Toggle SCL clock bit
        bcf     PORTA, SCL
        bsf     PORTA, SCL
        decfsz  bit_count           ; All bits shifted?
        goto    Shift_out           ; No, go shift next bit
        return

 end
```

either "turnright" or "turnleft." Wander is purely a reactive strategy in that it doesn't attempt to remember recent sensor states. More complex behaviors can be created by including some sort of sensor state memory, and I'll come back to this idea in future columns. Until then, this is left as an exercise for the reader.

Kit and Caboodle

I'm almost out of space, but I can't let you go without saying a few words about the Parallax GrowBot. I'll have a full review next month, but I'll give you a peek now.

As the photos show, GrowBot and Breadbot share some basic features: They are similar in size, both use hobby servos and disk wheels with O-ring tires, both use bow tie bumpers, both have front-wheel-drive with trailing casters, and both have battery packs slung underneath the robot chassis. GrowBot, like earlier versions of Breadbot, uses a BS2 as the controller, and both use their main circuit board as a chassis.

Unlike Breadbot, GrowBot has a much simplified trailing caster arrangement – a roller-skid, really – rather than a true caster and, on a bot this size, this works fine.

The three big differences are that GrowBot uses a PCB for its chassis instead of a solderless breadboard, GrowBot uses a separate 9V battery to power the controller (something I intend to do with Breadbot someday), and GrowBot can be expanded with stacking daughterboards that Parallax calls "AppModules." They've also thoughtfully provided a small piezo speaker, a couple LEDs, and more goodies on the main PC board.

This Bot is Stacked

I was impressed with the quality of the circuit board and the clean layout of all the components. The servos are mounted to the underside of the PCB with velcro, making for easy adjustments, and the 2 5/8 inch diameter wheels are custom made to fit directly on Futaba-style servo output shaft splines. If the wheels are reasonably priced, I predict that Parallax will do a healthy business just selling these wheels to gearheads.

The kit is easy to put together, with clear instructions – something that beginners will really appreciate. For those of you who are often convinced you can do better on your own, GrowBot's AppModules are a real plus, allowing endless customization.

AppModules are 2.5 inch square PC boards with a 20-pin stacking connector bus. All 16 of the BS2 I/O lines, plus ground, Vss, and Vdd are brought out on on GrowBot's two AppModule connectors. The two module types I received were the solderless Bread Board and the lower profile Proto Board.

The Proto Board has a stacking clearance height of 1/2", so you'll probably not be able to use standard wirewrap construction, but point-to-point will work just fine.

The Bread Board module has a 5/8" stacking clearance, though all components you plug into the solderless breadboard have less than 1/4" clearance if you plan to stack another AppModule on top. I still have lots more to say about GrowBot but, until next time, I'll just say both thumbs up for this kit.

I'm Outta Here

The book of the month this month is *Tube: The Invention of Television* by David E. Fisher and Marshall Jon Fisher, (Harcourt Brace & Co., 1997, ISBN 0-15-600536-0). You think television was invented in the 50s with Howdie Doodie and Gunsmoke?

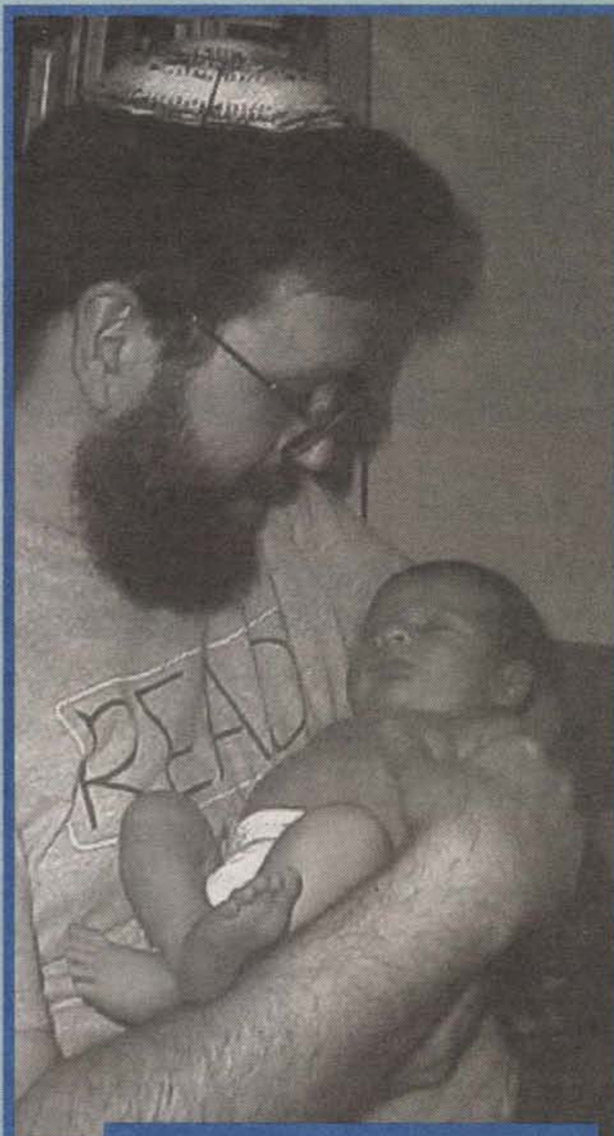
Read this book and discover that television was already over 50 years old by then. Philo Farnsworth transmitted an image with the first all-electronic television system in 1927, but mechanically scanned television schemes had been around long before that.

This book really puts technology development in perspective. Imagine trying to troubleshoot complex analog circuitry at a time when no one has even invented triggered sweep oscilloscopes. Talk about having to build the tools to build the tools you need to do a job!

Read this book, and I think you'll recognize a lot of the same spirit – and the same problems – that robot amateurs have today. Making electronic television work wasn't easy, obvious, or inevitable. Even as late as 1950, it was still possible that color TV would be in part mechanical.

In 1950, CBS's mechanical color was far superior to RCA's all-electronic system. We all might still have spinning mechanical color wheels inside our TVs if David Sarnoff of RCA hadn't done some fancy marketing footwork. Keep that in mind the next time you design the ultimate robot; there is more than one way to do anything, and it pays to explore as many alternatives as you can.

Whoops! Gotta go. Yonatan needs a diaper change. Hmm ... a diaper-changing robot is sounding better and better every day. **NV**



PROUD PAPA AND SON. Congratulations, Robert and Shoshana!!!

As always, if you have suggestions for improving Breadbot, if you've built a Breadbot, or if you have questions or comments about amateur robotics topics, you can reach me at:

Robert Nansel
69 S. Fremont Ave. #2
Pittsburgh, PA 15202
E-Mail: bnansel@nauticom.net

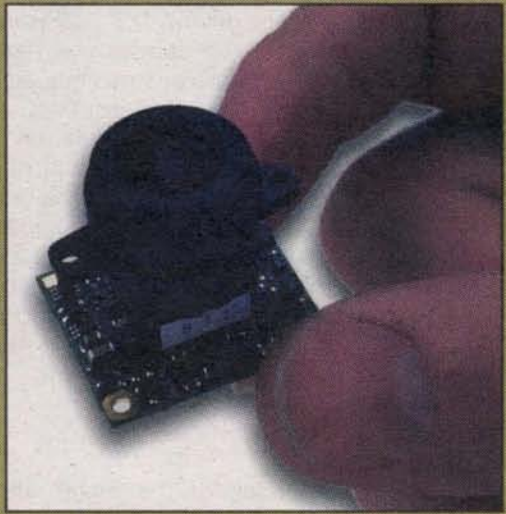
WIRELESS VIDEOTAPE COVERT VIDEO CAMERA

Supercircuits' new wireless videotape covert video camera gives a whole new meaning to the term "video feedback."

Concealed in an everyday videotape is a high resolution pinhole lipstick video camera, along with a long range 2.4 GHz, FCC-approved video transmitter.

Setting up video surveillance takes only minutes. Just place the videotape anywhere you want video eyes and ears. Then place the included receiver up to 300 feet away, and connect to your monitor or VCR. You'll view crisp, clear video and audio.

Available for only $379.95.



SUPER SMALL COLOR VIDEO CAMERA

Supercircuits introduces a new color video camera which is said to be the world's smallest color CCD unit. It is a diminutive 1.05" x .88" and weighs only 1/3 ounce!

Resolution is a sharp 350 lines and low-light rating is five lux.

The camera operates on five volts DC and draws only 160 milliamps.

The camera uses a revolutionary MCM PCB design and includes a new 10-bit digital signal processing chip.

Wide ranging applications include security, medical, videoconferencing, and robotics applications.

Available with standard microlens or covert pinhole style lens for under $100.00.

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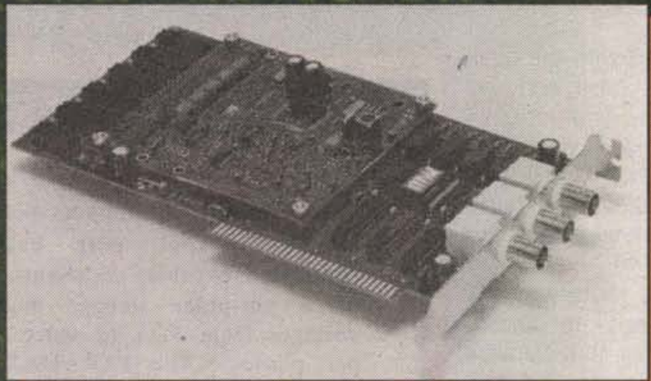

DDS7PC DIRECT DIGITAL SYNTHESIZER

Novatech Instruments, Inc. announces the model DDS7pc, a 68 MHz PC ISA bus card, bringing a new level of performance to plug-in synthesized signal generators.

Contained on an eight-bit ISA bus legacy card, the DDS7pc generates simultaneous ACMOS/TTL and sine outputs up to 68 MHz in 0.04 Hz steps under software control.

An external clock input allows multiple units to remain phase-synchronous and allows customer-configured frequency ranges. The sine output is programmable via an on-board step attenuator in 4 dB steps to 60 dB (1 Vrms to 1 mVrms).

The DDS7pc is ideal for programmable test stations and other applications requiring multiple and changing frequencies. Use of legacy eight-bit ISA bus permits nearly any PC compatible computer to become a test station based upon the DDS7pc.

The DDS7pc is available for $575.00.

For more information, contact:

NOVATECH INSTRUMENTS, INC.
17962 MIDVALE AVE. N., STE. 219
DEPT. NV
SHORELINE, WA 98133-4925
206-301-8986 FAX: 206-363-4367
E-MAIL: novatech@eskimo.com
WEB:
http://www.eskimo.com/~ntsales

New Product News

VELLEMAN TUBE AMPS

Velleman, Inc. announces the K8010 and K8011 tube amplifiers.

These are mono tube amplifiers, geared towards both hifi enthusiasts and musicians.

The K8010 is a high-end mono tube amp, capable of delivering 65 watts RMS in full class A, due to its four KT88 penthodes. The unit comes with a very attractive chrome plated enclosure.

The K8011 is a scaled down version, which still delivers 90 watts RMS class AB, with four EL34 penthodes. It comes without enclosure, but an optional chassis allows easy implementation in juke-boxes, guitar amps, and custom designs.

Both units are equipped with switch-on delay, stand-by mode, LED-bias indicators and custom-made toroidal supply and output transformers.

For more information, contact:

VELLEMAN, INC.
7415 WHITEHALL ST., STE. 119
DEPT. NV
FORT WORTH, TX 76118
817-284-7785 FAX: 817-284-7712
E-MAIL: velleman@earthlink.net
WEB: www.velleman.be

JAMECO ELECTRONIC'S NEW CATALOG

Jameco Electronics releases a new catalog and updated website.

Their free 148-page catalog features thousands of ICs, components, tools, test equipment, and computer products.

More than 215 new products have been added including new lines of test equipment.

For more information, contact:

JAMECO ELECTRONICS
1355 SHOREWAY RD., DEPT. NV
BELMONT, CA 94002
650-592-8097 FAX: 650-592-2503
E-MAIL: info@jameco.com
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NEW 1999 FULL-LINE CATALOG

Contact East introduces its largest catalog ever. View 308 pages of new tools and test instruments for engineers and technicians, as well as hobbyists.

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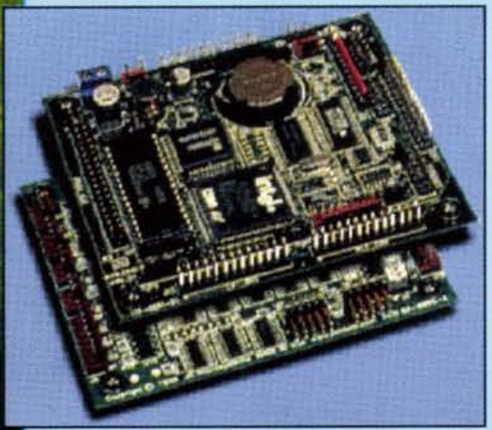

The Flashlite 386Ex embedded DOS controller, coupled with the new multi I/O peripheral boards, offers engineers a flexible, highly cost-effective solution to embedded control, data gathering, and monitoring problems. With up to eight channels of 12-bit A/D conversion, four channels of 12-bit D/A conversion, eight one-amp relay drivers, and two high-speed UARTs per board and up to eight boards per system, the multi I/O board is an expensive and compact data gathering solution.

The Flashlite 386Ex DOS controller features two PC-compatible serial ports, PC-compatible counter timers, interrupt controller, and 30 digital I/O points.

For more information, contact:

JK MICROSYSTEMS, INC.
1902 E. 8TH ST., DEPT. NV
DAVIS, CA 95616
530-297-6073 FAX: 530-297-6074
E-MAIL: jkmicro@jkmicro.com
WEB: http://www.jkmicro.com

RH-02 TEMPERATURE AND HUMIDITY LOGGER

RH-02 is a handy PC-based instrument which is able to measure both temperature and humidity in one compact unit. Using built-in sensors that are calibrated to give highly accurate measurements, RH-02 just plugs into the serial port of your PC and you are then ready to take measurements with the supplied PicoLog software (DOS and Windows 3.1, 95/98, and NT). The easy-to-use software lets you view graphs of the temperature and humidity simultaneously, export data to a spreadsheet, print and save data, and much more.

Alarm limits can be set to sound should the temperature or humidity go out of a specified range. The unit is also supplied with software drivers for those who wish to write their own application software.

Monitoring clean rooms, laboratories and computer facilities, checking heating and ventilation (HVAC) installations, and the monitoring of artifacts and documents in libraries and museums are all now easy and economical to accomplish with RH-02. The unit requires no power supply, so is ideal for use in the field with a laptop computer.

RH-02 measures temperatures from -40 to 70°C with accuracy of ±0.2°C (0 to 70°C) and humidity from 0 to 100% with accuracy of ±2% (5 to 95%).

RH-02 comes complete with manual and PicoLog software for $245.00.

For more information, contact:

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1193 MOSELEY RD., DEPT. NV
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